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REPORT NO. 1802

THE GIFT CODE USER MANUAL; VOLUME I.

INTRODUCTION AND INPUT REQUIREMENTS

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July 1975

USA BALLISTIC RESEARCH LABORATORIES
ABERDEEN PROVING GROUND, MARYLAND

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The GIFT code is a FORTRAN computer program. The basic input to the GIFT code is data called "target description data" which defines to any degree of accuracy the three-dimensional shape and space of the components of a tank, a building or any physical structure. Some of the GIFT code output options simulate engineering drawings and other graphic illustrations of the components of the physical structure or target as it is described in the input target description data. These output options document the target description data and are used to validate the accuracy of the input target description data. Output

20. ABSTRACT (CONTD)
options of the GIFT code compute, via analytical techniques, the intrinsic
characteristics of the modeled target such as the presented area, the centroids
of area and perimeter, the moments of inertia, the center of gravity, the
weight and the volume. The GIFT code also computes and outputs the angular and
spacial relationships between the modeled components and defined rays. The rays
are defined so that they simulate the behavior of projectiles, fragments or any
other physical particle paths. For example, for projectile and fragment target
vulnerability analysis, rays are defined which simulate the paths of projectiles
and fragments to and through the components of the modeled target. For every
projectile or fragment ray, the GIFT code identifies and outputs the following:
(1) the components of the target and the order that they are encountered along the
ray, (2) the normal and incidence angles between the components encountered by
the rays; (3) the distance through and between the encountered components that
the projectile or fragment must penetrate. For different analyses, the GIFT
code outputs different angular and spacial relationships: the output required
for target signature analysis is different from the output for target vulner-
ability analysis.

This report describes the target description data and other input require-
ments of the GIFT code. Another report, "The GIFT Code User Manual; Volume II,
The Output Options," is planned, which will describe the output options of the
GIFT code.

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1. INTRODUCTION

This report is a user's manual which describes the input requirements of the GIFT code. Another report, "The GIFT Code User Manual; Volume II, The Output Options," is planned, which will describe the output options of the GIFT code. Figure 1 is a flowchart of the input requirements and output options of the GIFT code.

The primary input to the GIFT code is "target description" data which defines the three-dimensional shape and spacial location of the components of a "target." A "target" may be a tank, a truck, a building or any other physical structure. To prepare target description data, engineering drawings, photographs, technical and reference manuals and/or any other data which describe the three-dimensional shape and space of components of the target are required. With only the prepared target description data as input, the GIFT code can output the following:

(a) An illustration of the components of the target (as modeled by the target description data) from the front, top, side or any view of the target. An example of a GIFT code illustration of target description data is displayed at the bottom of Figure 2. At the bottom of Figure 2 is the illustration of the target description data for the 20mm Towed Vulcan Cannon. (At the top of Figure 2 is a photograph of the 20mm Towed Vulcan Cannon.)

(b) Simulated engineering drawings of the components of the target described in the target description data.

(c) The projected area of the components of the target from the front, top, side or any view of the target.

(d) The centroids of area and perimeter of the target from any view.

(e) The volume of the components of the target.

(f) The angular and spacial values between the components of the target (geometric data on the target) required as input by the different "Target-Energy Effects" simulation codes.

When, in addition to the target description data, the densities of the components of the target are provided as input, the GIFT code can output the following:

(a) The moments of inertia of the target from any view of the target.

(b) The center of gravity of the target.

(c) The weight of the components of the target.

Engineering Drawings, Pictures,
Technical and Reference Manuals

Target
Description
Data

Density
for each
Component

Energy
Data

GIFT
CODE

Different
Geometric
Data
on the
Target

Different "Target
Energy Effects"*
Simulation
Codes

Physical Characteristics
of the Target: Picture
Representations, Area,
Centroids of Perimeter
and Area, Volume,
Weight, Moments,
Center of Gravity.

Different Analysis of the
Effects that the Energy
Source has upon the
Target.

*"Vulnerability Analysis" codes, "Target Signature" codes, etc.

Figure 1. Flowchart of the Input Requirements and Output Options of
the GIFT Code

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TOWED VULCAN
AZIMUTH 305.0   ELEVATION 45.0
SCALE IS 1.0 IN. = 36.00 UNITS
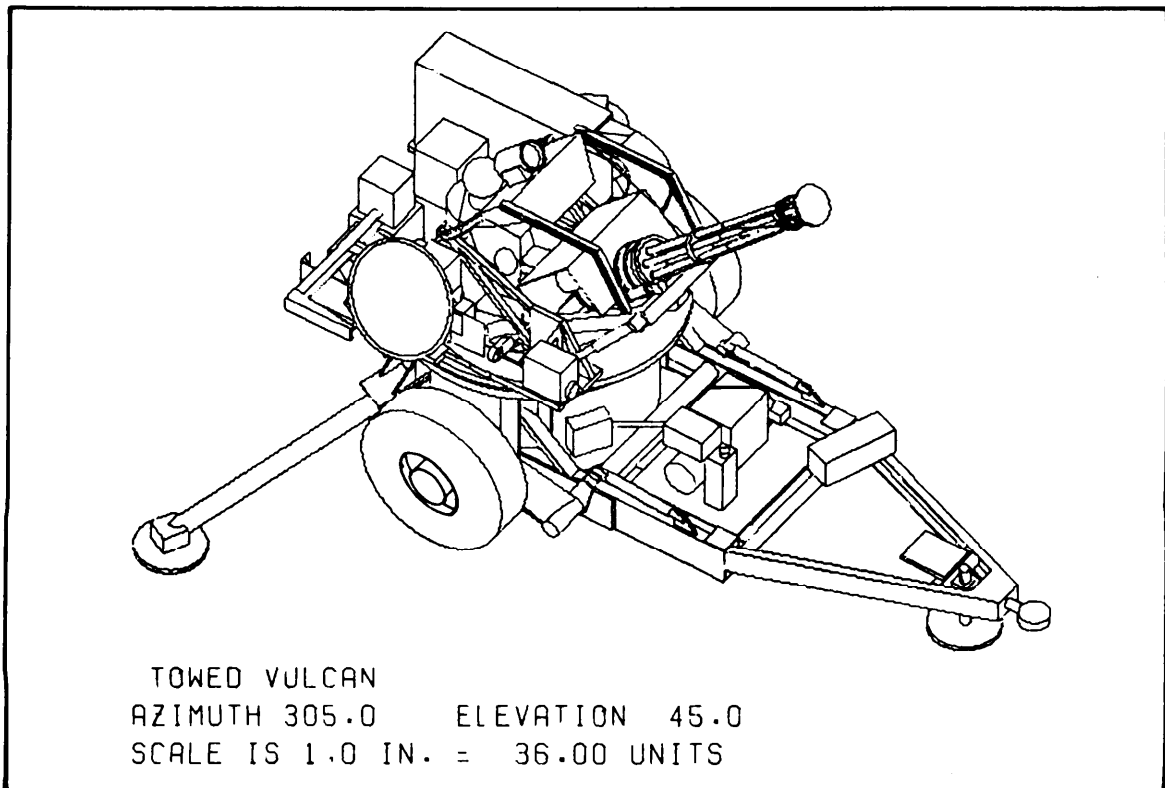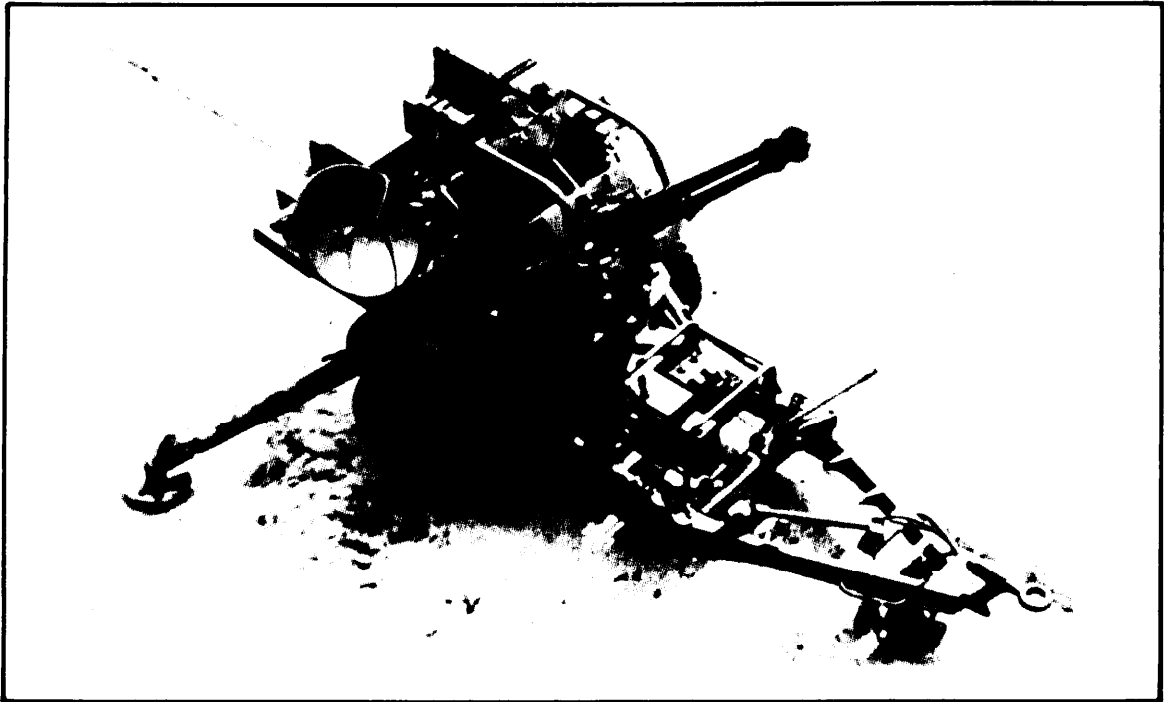
Figure 2. Picture and Illustration of Vulcan Cannon

The simulated engineering drawings and illustration outputs of the GIFT code illustrate how the components of the target are defined in the target description data. Thus, these output options of the GIFT code are used to document the shape and spacial locations of the components of the target as they are defined in the input target description data and to illustrate the accuracy of the input target description data. The remaining output options of the GIFT code are computations of the physical properties of the target which the GIFT code computes via analytical techniques. The analytical techniques within the GIFT code have been validated by comparing the output results of the GIFT code to measurements made via empirical test procedures.

The GIFT code can compute the physical properties of a prototype (concept) or a foreign vehicle before the physical vehicle is available for empirical measurements.

The GIFT code can compute many of the physical properties of a target much cheaper and faster than they can be measured via empirical test procedures. For the different "Target-Energy Effects" simulation codes, the GIFT code simulates the paths of different "energy sources" and computes and outputs thousands of angular and spacial values between the components of the target. The "vulnerability analysis" and the "target signature" codes are two examples of "Target-Energy Effect" simulation codes. For the "AVVAM-1"[1] and other "vulnerability analysis" codes, the GIFT code simulates the paths of projectiles and fragments (energy sources) through the target and computes and outputs the following for each simulated projectile and fragment path:

(a) A list of the components of the target as they are encountered by the simulated projectile or fragment.

(b) A thickness value for each component that the simulated projectile or fragment must penetrate.

(c) The angle of incidence between the simulated projectile and fragment paths and the surfaces of the encountered components.

Thus, for "vulnerability analysis" codes the GIFT code simulates projectile and fragment paths and outputs the type, the thickness and the angle of incidence of the components of the target encountered along the projectile and fragment paths. This GIFT code output is used as input to the "vulnerability analysis" codes which determine the damage that a given projectile or fragmentation mine would do to the components and thus to the "military functions" of the target. For example, if the target were a tank, then depending upon the components damaged, the tank's military functions of mobility or fire power may be reduced or made inoperative.

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[1] D. F. Haskell and M. J. Reisinger, "AVVAM-1 Armored Vehicle Vulnerability Analysis Model First Version," BRL Interim Memorandum Report No. 85, February 1973.

For the group of "Target-Energy Effects" simulation codes referred to as "target signature" codes, the GIFT code simulates the path of "signature energy sources" and computes and outputs the angular and spacial values of the components of the target that the different "target signature" codes require as input. An example of a "target signature" code is the "ETHM"[2] code. The "signature energy source" for the "ETHM" code is a beam of laser energy. The GIFT code simulates the paths of laser energy from an external source to the target and outputs the following data:

    (a)   The components of the target encountered by each laser path.

    (b)   The angle of incidence between the encountered components and the laser path.

    (c)   Data to determine the "angles of scattering" between the laser paths, the target and detectors.

Using the GIFT code data as input, the "ETHM" code simulates "the laser semi-active terminal homing situation" and outputs "intensity versus time data for each laser pulse and for each quadrant of a four-quadrant detector."[2]

1.1 Background

The Air Target Vulnerability Sub-Group of the Joint (Army, Navy, Air Force) Technical Coordinating Group for Munitions Effectiveness (JTCG/ME) evaluated, selected and sponsored the detailed documentation of the MAGIC[3] and the SHOT GENERATOR[4] codes. These two codes use different techniques to prepare target description data, while both codes output the angular and spacial values of the target required as input by "vulnerability analysis" codes. The techniques employed within these and other codes, and the comments, the suggestions and the needs of potential users were evaluated and influenced the development of the GIFT code.

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[2] K. E. Joel and L. J. Vande Kieft, "Computer Model for Laser Semi-Active Terminal Homing," BRL Memorandum Report No. 2419, USA Ballistic Research Laboratories, Aberdeen Proving Ground, Maryland, November 1974 (AD B000896).

[3] NWC Technical Note 4565-3-70, Volumes I & II; "SHOT GENERATOR Computer Program, Volume I, User Manual; Volume II, Analyst Manual," by Armament Systems, Inc., and Propulsion Development Department, July 1970. (Available from Department of the Navy, Naval Weapons Center, China Lake, CA 93555).

[4] NWC Technical Note 4565-3-71; Volumes I & II; "MAGIC Computer Simulation, Volume I, User Manual; Volume II, Analyst Manual," by Armament Systems, Inc., and Propulsion Development Department, May 1971 (Available from Department of the Navy, Naval Weapons Center, China Lake, CA 93555).

1.2 Objectives

The objective of this report is to describe the input requirements of the GIFT code for potential users.

The objectives established for the target description data used as input by the GIFT code were as follows:

   (a) To minimize the amount of time and the cost to prepare the target description data.

   (b) To develop the target description technique so the user could describe any target as accurately as he desires.

   (c) To assure that the target description data prepared for use by other codes such as MAGIC and SHOT GENERATOR codes could be converted for use by the GIFT code. (A BRL report is being prepared on a code which converts target description data for the MAGIC code into target description data for the GIFT code.)

The objectives established for the computational techniques coded within the GIFT code were as follows:

   (a) To organize the subroutines of GIFT code so that they are a library of basic functions which can be utilized to compute and output the angular and spacial values of the target required as input by any "Target-Energy Effects" simulation code.

   (b) To develop and code the computation techniques within the GIFT code so the minimum amount of computer run time (CPU time) is used to compute the different output options. (A comparison of the CPU time for the GIFT, SHOT GENERATOR, and MAGIC code was made: to compute the same output data for the same target, the CPU time for the GIFT code was 38.626 seconds; the CPU time for the SHOT GENERATOR code was 44.305 seconds, while the CPU time for the MAGIC code was 2 minutes, 36.560 seconds.)

1.3 Utilization of the GIFT Code

The amount of computer core memory required to run the GIFT code varies with the amount of input data.

The GIFT code consists of approximately 7,000 cards or lines of coding and 3,000 lines containing comments (comment cards) which document the GIFT code. (An analyst manual of the GIFT code is also planned.) Because of the large number of lines (about 10,000) in the GIFT code, a listing or printout of the GIFT code is not contained within this report.

BRLESC (a BRL-built computer), CDC, UNIVAC and IBM FORTRAN versions of the GIFT code are available. Each version of the GIFT code is slightly different because of the differences between the computer systems; however, the input requirements of the GIFT code, presented in this report, are the same for every computer system.

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In the remaining sections of this report the fundamentals of the target description technique used to prepare and the exact input requirements of the GIFT code are presented. As the following sections define the different input requirements, input is generated for a sample target to illustrate the input requirements.

The input data generated for the sample target in this report is used as input to the GIFT code and the resulting output is contained in "The GIFT Code User Manual; Volume II, The Output Options," to illustrate the different output options of the GIFT code.

Besides the input requirements, procedural recommendations, based upon experience, are presented in this report which should aid in the preparation of the GIFT code input requirements and thus aid in the utilization of the GIFT code.

2. TARGET DESCRIPTION DATA

Target description data defines or models the three-dimensional shape and space of a simple or complex physical structure - the target. The GIFT code uses a "combinatorial geometry" or "COM-GEOM" target description technique. This technique defines the shape and space of the components of the target as a single geometric "solid" (a box, a sphere, a cylinder, etc.), or the "combination" of several geometric solids. The parameters which define the spacial locations of the geometric solids used to model the components of the target are recorded in the "Solid Table." Each component (region) of the target is defined as a single solid or a "combination" of solids in the "Region Table."

The Solid and the Region Tables, and the other input data required to create the target description data for the GIFT code are defined in the following sections of this report.

2.1 Preliminary Steps

The first step to model a target by any three-dimensional target description technique is to obtain engineering drawings, reports, or any other data which exhibit the physical dimensions of the target. The next step is to define a reference point on the target: the origin point (0) of an X,Y,Z right-handed coordinate system. For example, for tanks, the intersection of the turret datum line and the center lines of the turret is usually selected as the origin point. Figure 3 exhibits a right-handed X,Y,Z coordinate system superimposed onto the front, side and top view of a tank. The parameters within the target description data may be recorded in inches or centimeters or any other unit of measure. For example, the X,Y,Z coordinate values for point "P" on Figure 3 can be approximately measured as (X = 1.4, Y = 1.0, Z = -1.0) inches or (X = 3.5, Y = 2.5, Z = -2.5) centimeters from the origin point (X,Y,Z = 0). Every parameter recorded in the target description data must be measured in the same unit of measure.

TOP VIEW

X

O

P

Y

Z

Z

X

O

Y

O

Z

X

O

P

SIDE VIEW

FRONT VIEW

P
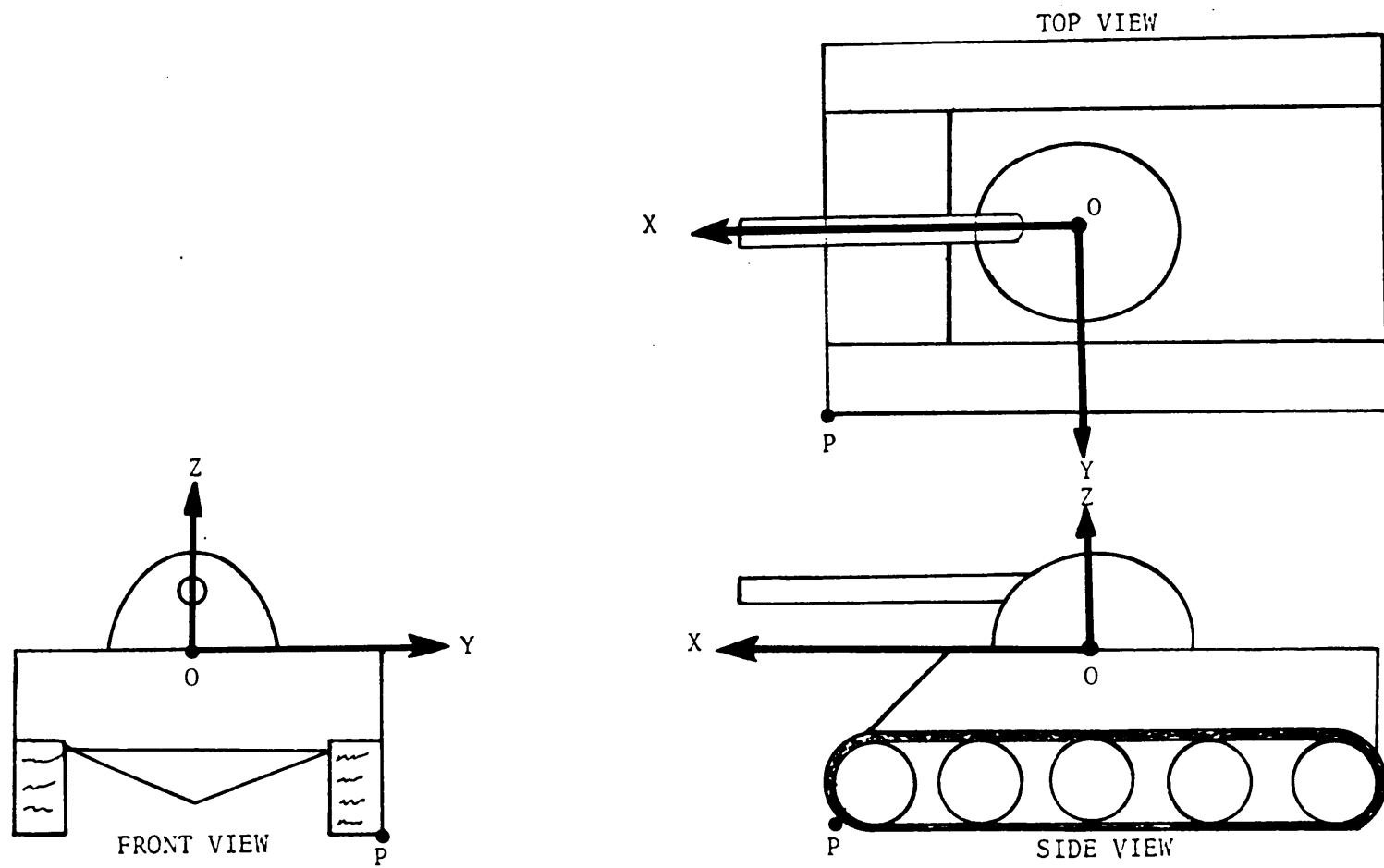
Figure 3.   Right-Handed Coordinate System Superimposed Onto a Tank

2.2 Solids

Table 1 lists the twelve geometric solids used by the GIFT code. The three letters under the "SYMBOL" column are the alpha designation used in this report and on the input cards for the solid. The "REFERENCE" column lists the figure(s) and page number(s) where the input data for the solid is described.

On Figure 4, the space and shape of a BOX and two SPH's are illustrated as three-dimensional (X,Y,Z) solids. Each illustrated solid is identified by a unique number (1, 2, 3). This permits the space of the SPH numbered "2" to be distinguished from the space of the SPH numbered "3" and the BOX numbered "1".

The parameters required to define the twelve solids are different; however, the parameters can be classified as being either a "vertex point," a "vector," or a "scalar."

A vertex point is a point defined by its X, Y and Z measurements (coordinate values) from the target reference or origin (0) point. Point "P" on Figure 3, as defined in section 2.1, is a vertex point. For each of the twelve types of solids, at least one vertex point is used to locate the position of the solid in the referenced X,Y,Z space. For example, "$\overline{V}$" is the vertex point for "1 BOX" on Figure 4, while the centerpoints "$\overline{C}_2$ and $\overline{C}_3$" of "2 and 3 SPH," respectively, are the vertex points for the sphere solids. (Within this report, the dash (—) mark over a letter ($\overline{V}$, $\overline{C}_2$, $\overline{C}_3$) will be used to indicate an X, Y and Z measurement.)

Certain solids require vector parameters to define the three-dimensional shape and space that they occupy. The BOX requires three vectors, $\overline{H}$, $\overline{W}$, $\overline{D}$, which respectively represent the height, width and depth of the BOX. Vectors also have an X, Y and Z measurement; however, the measurements of vectors are taken from the vertex point of the solid rather than the target reference or origin point. The X,Y,Z measurements of $\overline{H}$, $\overline{W}$ and $\overline{D}$ vectors are taken from $\overline{V}$, not the origin (0) point.

Some solids require scalar parameters to define their shape and space. Scalars are single numeric values. An example of a scalar is the radium parameter used to define the SPH solid. "R2" on Figure 4 is the radius for "2 SPH," while "R3" is the radius for "3 SPH".

Figures 5 to 20 illustrate and define the parameters, card input formats for each of the 12 solid types used by the GIFT code. The comments on these figures must be given careful attention because the difference between certain solids is slight.

. Figure 21 displays the front and top view drawings of a sample target (a car and a driver). A right-handed X, Y and Z coordinate system superimposed over the engineering drawings of the sample target and a unit scale is also displayed on Figure 21.

Table 1. The 12 Geometric Solids Used by the GIFT Code

	SOLID NAME	SYMBOL	REFERENCE
1.	Rectangular Parallelepiped	RPP	Fig. 5. Page 20
2.	Box .	BOX	Fig. 6. Page 21
3.	Right Angle Wedge	RAW	Fig. 7. Page 22
4.	Arbitrary Convex Polyhedrons	ARB	Figs. 8 to 12. Pages 23 to 27
5.	Triangular Surfaced Polyhedrons	ARS	Fig. 13. Page 28, 29
6.	Ellipsoid of Revolution	ELL	Fig. 14. Page 30
7.	Sphere	SPH	Fig. 15. Page 31
8.	Right Circular Cylinder	RCC	Fig. 16. Page 32
9.	Right Elliptical Cylinder	REC	Fig. 17. Page 33
10.	Truncated Right Angle Cone	TRC	Fig. 18. Page 34
11.	Truncated Elliptical Cone	TEC	Fig. 19. Page 35
12.	Torus	TOR	Fig. 20. Page 36
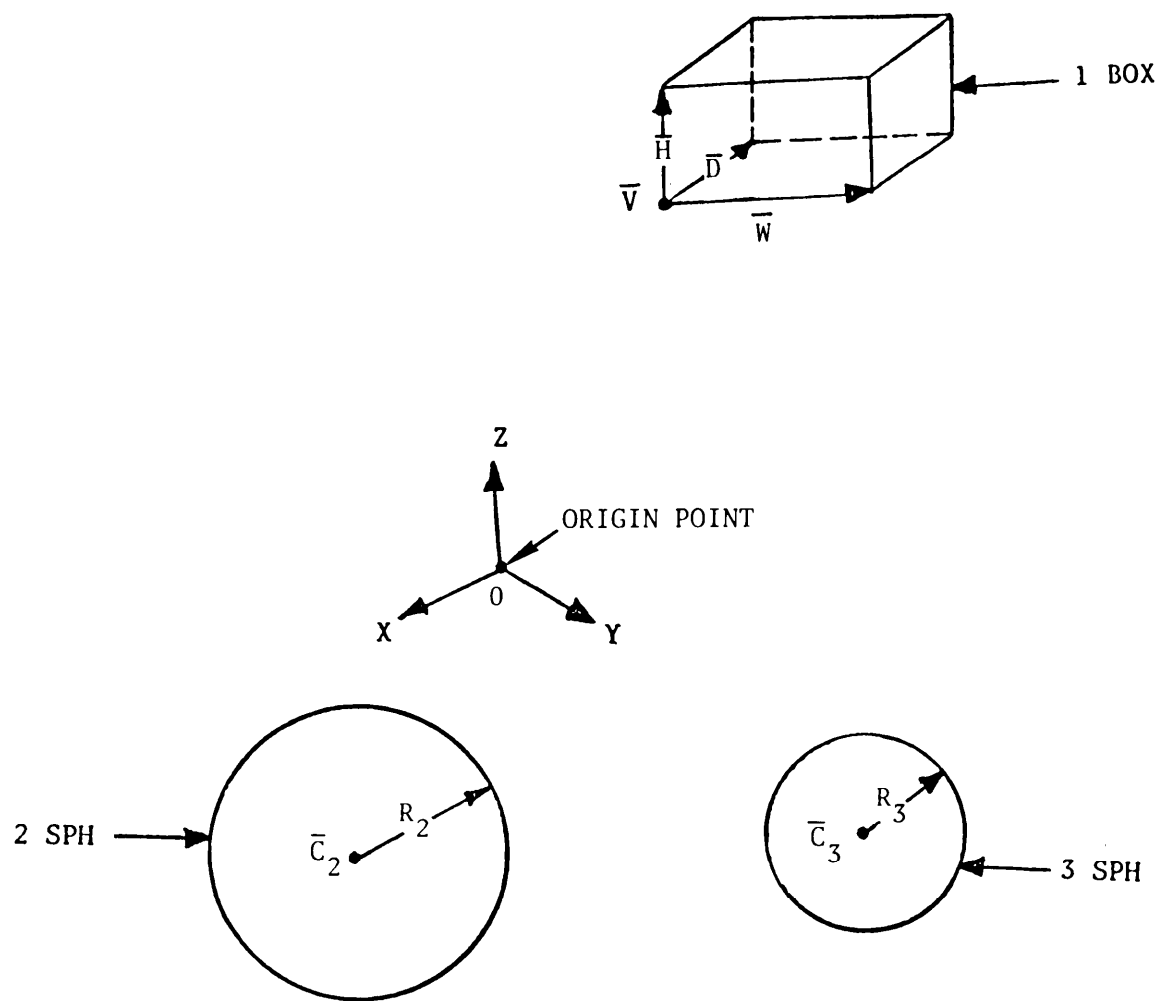
Figure 4. A BOX and Two SPH's in Space
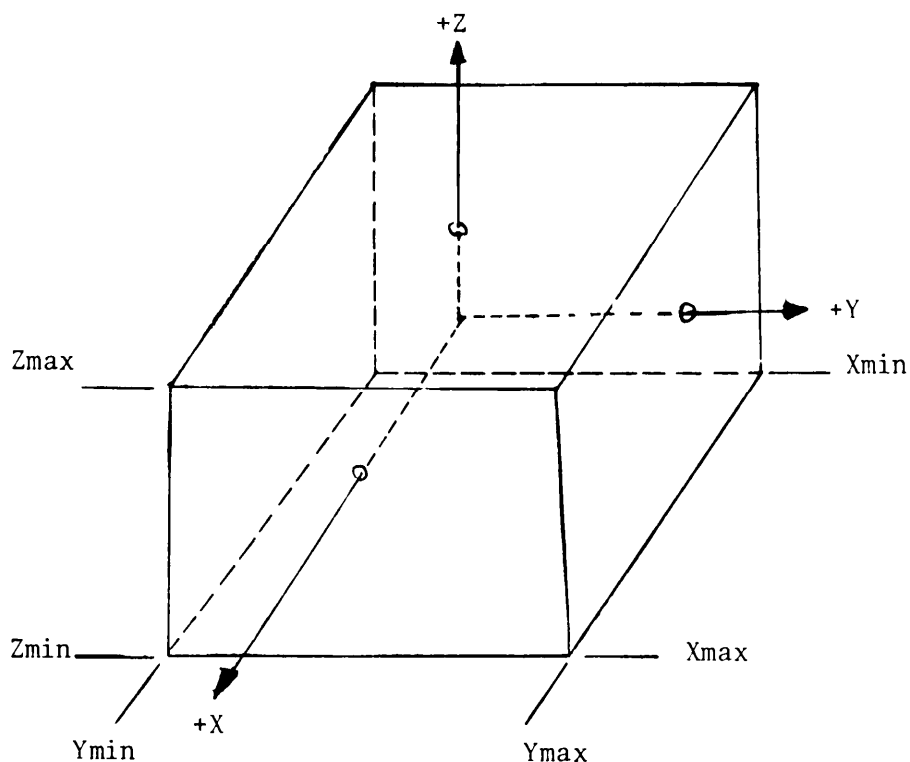
SPECIFY: The maximum (max) and the minimum (min) values of the X, Y, Z coordinates which bound the parallelpiped.

NOTE: The bounding planes must be parallel to the coordinate axes of the target.
         The RPP is the only solid which does not specify a vertex point.
         The sixth solid on Table 2 is an RPP.
         *Card Columns 71-80 are used for comments as the word "BODY" appears on the RPP card on Table 2.
         Card Format: (A1, A2, A3, A4, 6F10.5, 2A5)

CARD COLUMNS*

1-3	4-6	11-20	21-30	31-40	41-50	51-60	61-70	Number of Cards
Solid Number	RPP	Xmin	Xmax	Ymin	Ymax	Zmin	Zmax	1 of 1

Figure 5.   Rectangular Parallelepiped (RPP) Input

20
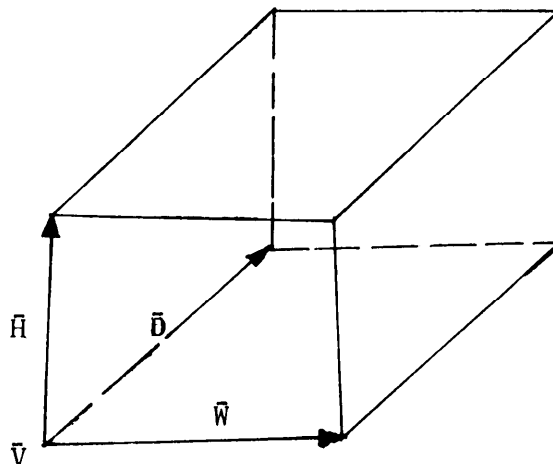
SPECIFY: The vertex ($\overline{V}$) at one of the corners by giving the X, Y, Z
coordinates. The X, Y, Z components of the three mutually
perpendicular vectors ($\overline{H}$, $\overline{W}$, $\overline{D}$) from the vertex point $\overline{V}$,
representing the height, width, and depth of the box.

NOTE: The box may be arbitrarily oriented while the RPP must be
parallel to the reference coordinate axes.
The vectors, $\overline{H}$, $\overline{W}$, $\overline{D}$ may be interchanged on the card input.
The twentieth solid on Table 2 is a BOX.
*Card Columns 71-80 are used for comments.
Card Format: (A1, A2, A3, A4, 6F10.5, 2A5)

CARD COLUMNS*

1-3	4-6	11-20	21-30	31-40	41-50	51-60	61-70	Number of Cards
Solid Number	BOX	Vx	Vy	Vz	Hx	Hy	Hz	1 of 2
Solid Number		Wx	Wy	Wz	Dx	Dy	Dz	2 of 2

Figure 6. Box (BOX) Input

21
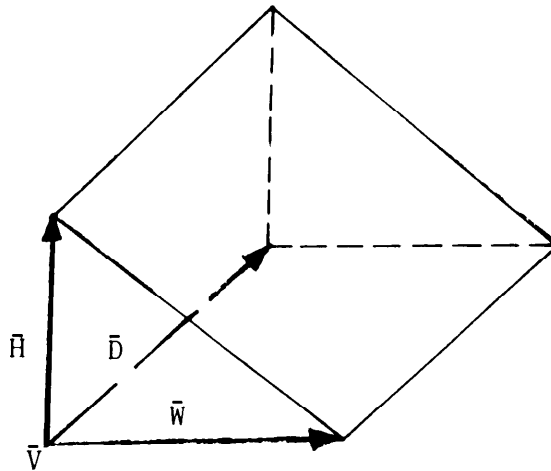
SPECIFY: The vertex (V̄) at one of the right-angled corners by giving the X, Y and Z coordinate. The components of the three mutually perpendicular vectors (H̄, W̄, D̄), of which two (H̄, W̄) are the legs of the right triangle formed while the third (D̄) is the depth of the wedge.

NOTE: The two legs H̄, W̄ may be interchanged on card input, but the D̄ vector must remain in position shown.
The twelfth solid on Table 2 is a RAW.
*Card Columns 71-80 are used for comments.
Card Format: (A1, A2, A3, A4, 6F10.5, 2A5)

CARD COLUMNS*

1-3	4-6	11-20	21-30	31-40	41-50	51-60	61-70	Number of Cards
Solid Number	RAW	Vx	Vy	Vz	Hx	Hy	Hz	1 of 2
Solid Number		Wx	Wy	Wz	Dx	Dy	Dz	2 of 2

Figure 7. Right Angle Wedge (RAW) Input

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SPECIFY: The X, Y, X coordinates of the eight vertices of the poly-
hedron. Vertices are the ordinal numbers $\bar{1}$ to $\bar{8}$ on the
figure.

NOTE: This form of the ARB has eight (8 in card column 7) vertices
and six faces each defined by four vertices.
The GIFT code identifies the six faces as:
1234, 5678, 1584, 2376, 1265, and 4378.
The fourth solid on Table 2 is ARB8.
*Card Columns 71-80 are used for comments.
Card Format: (A1, A2, A3, A4, 6F10.5, 2A5)

CARD COLUMNS*

1-3	4-6	7	11-20	12-30	31-40	41-50	51-60	61-70	Number of cards
Solid Number	ARB	8	1x	1y	1z	2x	2y	2z	1 of 4
Solid Number			3x	3y	3z	4x	4y	4z	2 of 4
Solid Number			5x	5y	5z	6x	6y	6z	3 of 4
Solid Number			7x	7y	7z	8x	8y	8z	4 of 4

Figure 8. Six-Faced, Eight Vertices, Convex Polyhedron (ARB8) Input

SPECIFY: The X, Y, Z coordinates of the seven vertices of the
            polyhedron. Vertices are the ordinal number $\bar{1}$ to $\bar{7}$
            on the figure.

NOTE: This form of the ARB has seven ("7" in card columns "7")
            vertices and six faces - four faces defined by four
            vertices, two faces defined by three vertices (triangular
            faces).

            The GIFT code generates the six faces as:
            1234, 567, 145, 2376, 1265, 4375.
            There is no sample of the ARB7 on Table 2.
            *Card Columns 71-80 are used for comments
            Card Format: (A1, A2, A3, A4, 6F10.5, 2A5)

CARD COLUMNS*

1-3	4-6	7	11-20	21-30	31-40	41-50	51-60	61-70	Number of Cards
Solid Number	ARB	7	1x	1y	1z	2x	2y	2z	1 of 4
Solid Number			3x	3y	3z	4x	4y	4z	2 of 4
Solid Number			5x	5y	5z	6x	6y	6z	3 of 4
Solid Number			7x	7y	7z				4 of 4

Figure 9. Six-Faced, Seven Vertices, Convex Polyhedron (ARB7) Input
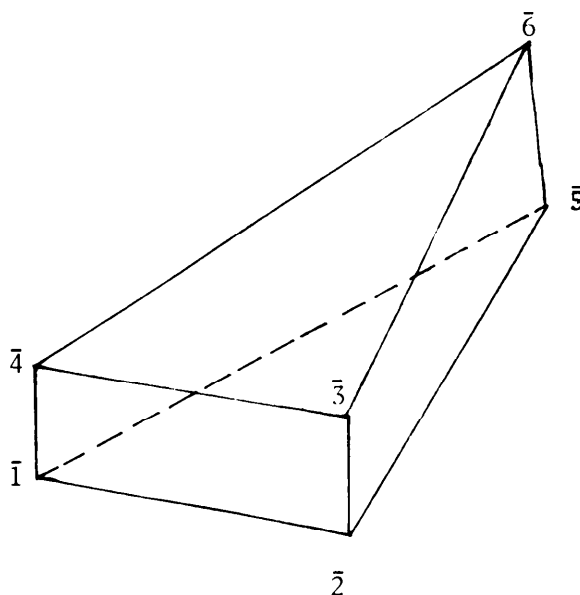
SPECIFY: The X, Y, Z coordinates of the six vertices of the polyhedron. Vertices are the ordinal numbers 1 to 6 on the figure.

NOTE: This form of the ARB has six ("6" in card column "7") vertices and five faces - three faces are defined by four vertices, two faces defined by three vertices. The GIFT code generates the five faces as: 1234, 2365, 1564, 512, 634. There is no sample of the ARB6 on Table 2.
*Card Columns 71-80 are used for comments.
Card Format: (A1, A2, A3, A4, 6F10.5, 2A5)

CARD COLUMNS *

1-3	4-6	7	11-20	21-30	31-40	41-50	51-60	61-70	Number of Cards
Solid Number	ARB	6	1x	1y	1z	2x	2y	2z	1 of 3
Solid Number			3x	3y	3z	4x	4y	4z	2 of 3
Solid Number			5x	5y	5z	6x	6y	6z	3 of 3

Figure 10. Five-Faced, Six Vertices, Convex Polyhedron (ARB6) Input

SPECIFY: The X, Y, Z coordinates of the five vertices of the polyhedron. Vertices are the ordinal numbers 1̄ to 5̄ on the figure.

NOTE: This form of the ARB has five ("5" in card column "7") vertices and five faces - one face defined by **four** vertices, four faces defined by three vertices. The GIFT code generates the five faces as: 1234, 512, 523, 534, 541. The third solid on Table 2 is an ARB5. *Card Columns 71-80 are used for comments. Card Format: (A1, A2, A3, A4, 6F10.5, 2A5)

CARD COLUMNS*

1-3	4-6	7	11-20	21-30	31-40	41-50	51-60	61-70	Number of Cards
Solid Number	ARB	5	1x	1y	1z	2x	2y	2z	1 of 3
Solid Number			3x	3y	3z	4x	4y	4z	2 of 3
Solid Number			5x	5y	5z				3 of 3

Figure 11. Five-Faced, Five Vertices, Convex Polyhedron (ARB5) Input
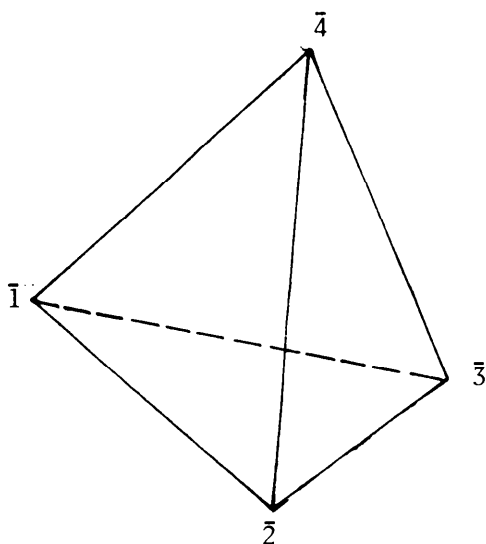
SPECIFY: The X, Y, Z coordinates of the four vertices of the polyhedron. Vertices are the ordinal numbers 1̄ to 4̄ on the figure.

NOTE: This form of the ARB has four ("4" in card column "7") vertices and four faces each defined by three vertices. The GIFT code generates the four faces as: 123, 412, 423, 431.
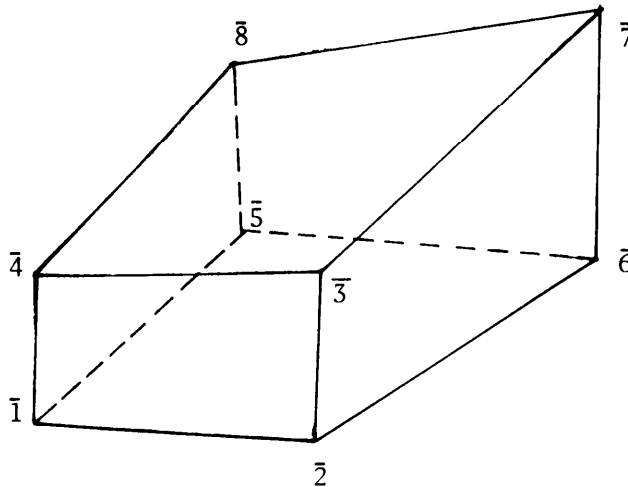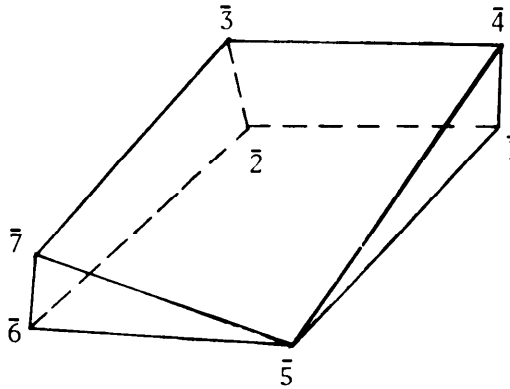The second solid on Table 2 is an ARB4.
*Card Column 71-80 are used for comments.
Card Format: (A1, A2, A3, A4, 6F10.5, 2A5)

CARD COLUMNS*

1-3	4-6	7	11-20	21-30	31-40	41-50	51-60	61-70	Number of Cards
Solid Number	ARB	4	1x	1y	1z	2x	2y	2z	1 of 2
Solid Number			3x	3y	3z	4x	4y	4z	2 of 2

Figure 12.   Four-Faced, Four Vertices, Convex Polyhedron (ARB4) Input

27

SPECIFY: The X, Y, Z coordinate values of the vertices of the
           concave or convex polyhedron. Either 1) order and
           record the vertices by the number of curves (M) and
           number of points per curve (N) system or 2) order and
           record the vertices by the scheme associated with the
           SHOT GENERATOR Code and specify the number of recorded
           points (ND).

Figure 13.   Triangular Surfaced (ARS) Polyhedron Input
                      Sheet 1 of 2

NOTE: The ordering schemes are vaguely presented because the pur-
pose of this solid type is to permit the easy conversion
and use of target description data of other codes. It is
recommended to model polyhedrons as a "combination"
(explained in later sections) of ARB's 4, 5, 6, 7 and 8's.
The sample polyhedron has 10 unique vertices ($\bar{1}$, $\bar{2}$, $\bar{3}$...$\overline{10}$);
however, M = 4, N = 5 and 4 x 5 or 20 vertices are required and
recorded to generate the triangular faces of this polyhe-
dron — order is illustrated by the M,N matrix above and the
vertices of the generated triangle faces are connected by
dashes (— —).
Each new curve begins on a new card: when N is odd, the
card containing the last recorded point of a curve is fol-
lowed by blanks in card columns 41-70.
The eleventh solid on Table 2 is an ARS.

CARD COLUMNS

1-3	4-6	11-20	21-30	31-40	41-50	51-60	61-70	Number of Cards
Solid Number	ARS	M	N	ND				1 of n
Solid Number		X(1,1)	Y(1,1)	Z(1,1)	X(1,2)	Y(1,2)	Z(1,2)	2 of n
⋮		⋮						⋮
Solid Number		X(1,N)	Y(1,N)	Z(1,N)				$1+(\frac{N+1}{2})$ of n
Solid Number		X(2,1)						
⋮		⋮						
Solid Number		X(M,1)						
⋮		⋮						
Solid Number		X(M,N)	Y(M,N)	Z(M,N)				$n=1+M(\frac{N+1}{2})$

Figure 13. Triangular Surfaced (ARS) Polyhedron Input
Sheet 2 of 2
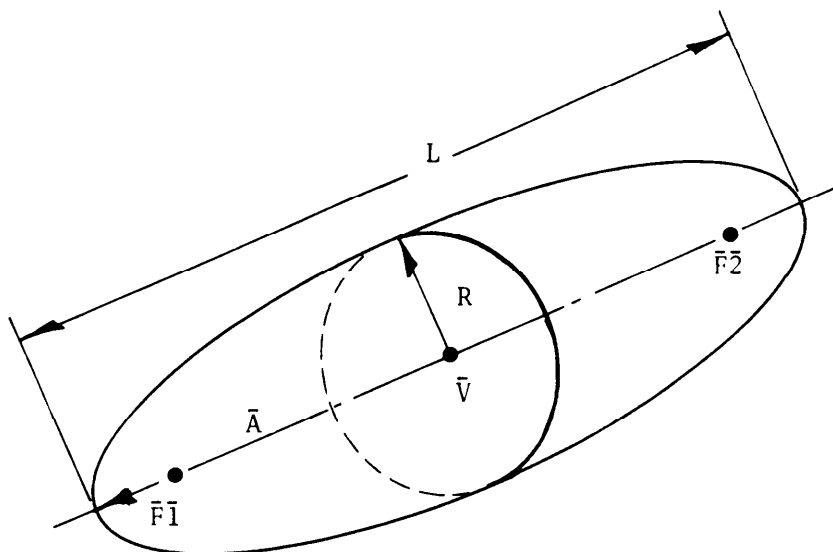
SPECIFY: Either (1) the X, Y, Z coordinates of foci $\overline{F1}$ and $\overline{F2}$ (vertex points) and the scalar L denoting the length of the major axis or (2) the X, Y, Z coordinates of the vertex $\overline{V}$ at the center of the major axis, the vector $\overline{A}$ defining the semi-major axis, and the scalar R denoting the radius of the circular section taken at the center point $\overline{V}$.

NOTE: A number "1" in card column "7" denotes the second input option.
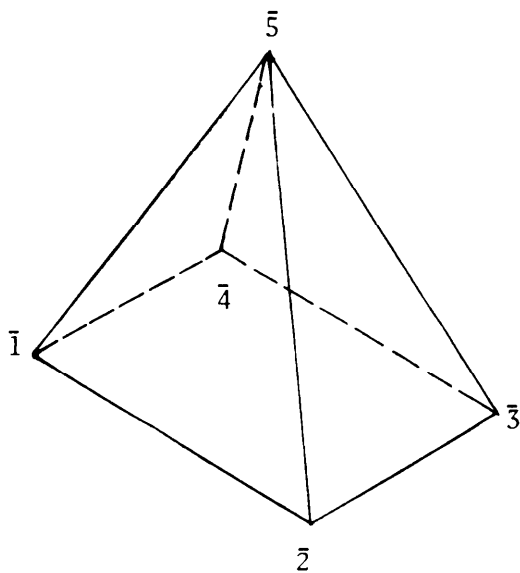The fifth solid on Table 2 is an ELL and the nineteenth solid is an ELL1.
*Card Columns 71-80 are used for comments.
Card Format: (A1, A2, A3, A4, 6F10.5, 2A5).

CARD COLUMNS*

1-3	4-6	11-20	21-30	31-40	41-50	51-60	61-70	Number of Cards
Solid Number	ELL	F1x	F1y	F1z	F2x	F2y	F2z	1 of 2
Solid Number		L						2 of 2

1-3	4-6	7	11-20	21-30	31-40	41-50	51-60	61-70	Number of Cards
Solid Number	ELL	1	Vx	Vy	Vz	Ax	Ay	Az	1 of 2
Solid Number			R						2 of 2

Figure 14. Ellipsoid of Revolution (ELL) Input

SPECIFY: The vertex $\bar{V}$, the center point, and scalar R denoting the radius.

NOTE: The fourteenth solid on Table 2 is a SPH.
*Card Columns 71-80 are used for comments.
Card Format: (A1, A2, A3, A4, 6F10.5, 2A5)

CARD COLUMNS *

1-3	4-6	11-20	21-30	31-40	41-50	51-60	61-70	Number of Cards
Solid Number	SPH	Vx	Vy	Vz	R			1 of 1

Figure 15. Sphere (SPH) Input

31
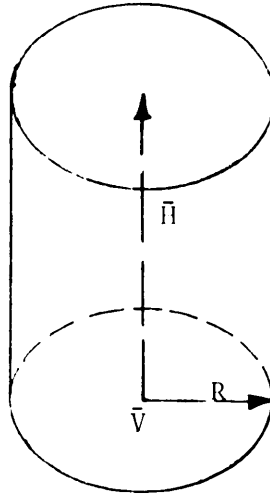
SPECIFY: The vertex point $\bar{V}$ at the center of one base, height vector $\bar{H}$ and scalar R denoting the base radius.

NOTE: The seventh, eighth, ninth and tenth solids on Table 2 are RCC's.

*Card Columns 71-80 are used for comments.

Card Format: (A1, A2, A3, A4, 6F10.5, 2A5).

CARD COLUMNS*

1-3	4-6	11-20	21-30	31-40	41-50	51-60	61-70	Number of Cards
Solid Number	RCC	Vx	Vy	Vz	Hx	Hy	Hz	1 of 2
Solid Number		R						2 of 2

Figure 16. Right Circular Cylinder (RCC) Input

32
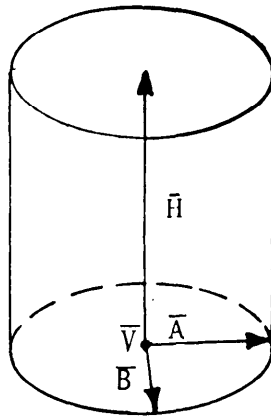
SPECIFY: The X, Y, Z coordinates of the center of the base
ellipse $\bar{V}$, height vector $\bar{H}$, and vectors $\bar{A}$ and $\bar{B}$
in the base plane defining the semi-major and semi-
minor axes, respectively.

NOTE: The thirteenth solid on Table 2 is an REC.
*Card Columns 71-80 are used for comments.
Card Format: (A1, A2, A3, A4, 6F10.5, 2A5).

CARD COLUMNS *

1-3	4-6	11-20	21-30	31-40	41-50	51-60	61-70	Number of Cards
Solid Number	REC	Vx	Vy	Vz	Hx	Hy	Hz	1 of 2
Solid Number		Ax	Ay	Az	Bx	By	Bz	2 of 2

Figure 17. Right Elliptical Cylinder (REC) Input

33
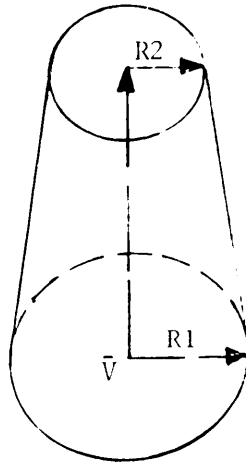
SPECIFY: The vertex $\bar{V}$ at the center of the larger base, height vector $\bar{H}$ and scalars R_1 and R_2 denoting the radii of the larger and smaller bases respectively.

NOTE: The seventeenth and eighteenth solids on Table 2 on page 39 are TRC's.

*Card Columns 71-80 are used for comments.

Card Format: (A1, A2, A3, A4, 6F10.5, 2A5).

CARD COLUMNS*

1-3	4-6	11-20	21-30	31-40	41-50	51-60	61-70	Number of Cards
Solid Number	TRC	Vx	Vy	Vz	Hx	Hy	Hz	1 of 2
Solid Number		R_1	R_2					2 of 2

Figure 18.   Truncated Right Angle Cone (TRC) Input

34
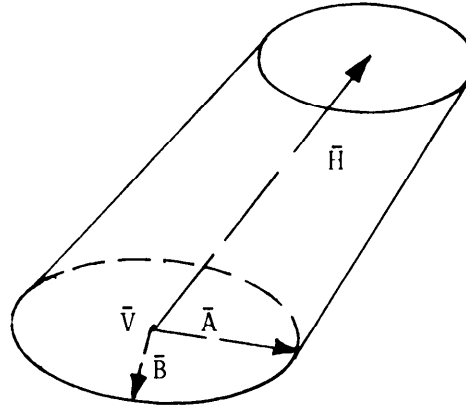
SPECIFY: The coordinates of vertex $\bar{V}$ at the center of the
larger ellipse, and the X, Y, Z components of the
height vector $\bar{H}$ and vectors $\bar{A}$ and $\bar{B}$ describing the
semi-major and semi-minor axes. The ratio P of the
larger to smaller ellipse.

NOTE: The height vector $\bar{H}$ does not have to be perpendicular
to the plane containing vectors $\bar{A}$ and $\bar{B}$.
The ratio P may be determined by the magnitude (length)
of semi-major vector $\bar{A}$ of the base ellipse divided by
the length of semi-major axis of the upper ellipse: P > 1,
The fifteenth and sixteenth solids on Table 2 are TEC's.

*Card Columns 71-80 are used for comments.
Card Format: (Al, A2, A3, A4, 6F10.5, 2A5)

CARD COLUMNS *

1-3	4-6	11-20	21-30	31-40	41-50	51-60	61-70	Number of Cards
Solid Number	TEC	Vx	Vy	Vz	Hx	Hy	Hz	1 of 3
Solid Number		Ax	Ay	Az	Bx	By	Bz	2 of 3
Solid Number		P						3 of 3

Figure 19.   Truncated Elliptic Cone (TEC) Input

35
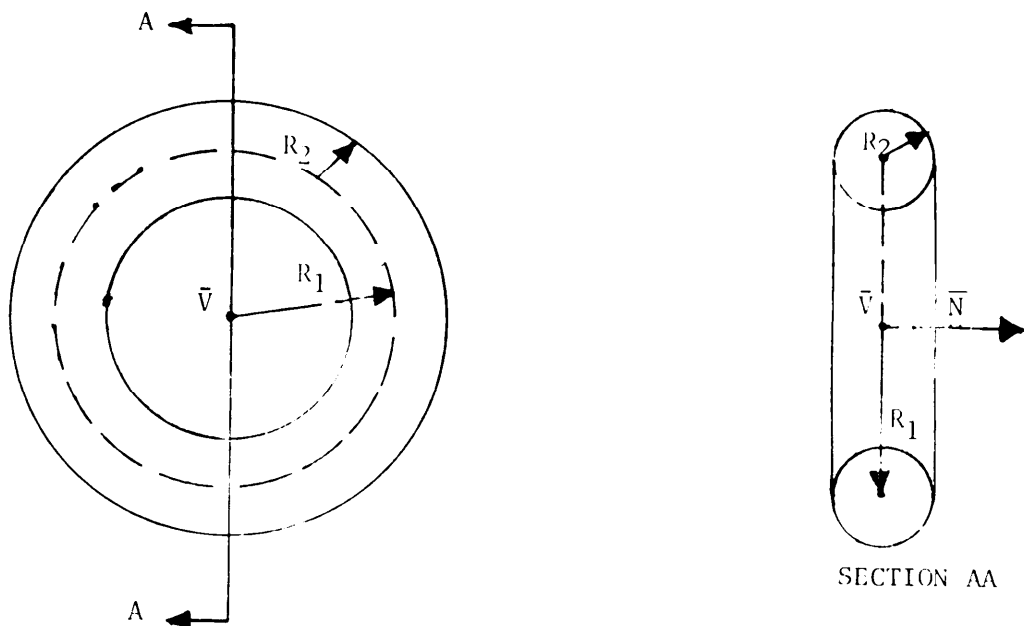
SECTION AA

SPECIFY: The vertex $\bar{V}$ at the center of the torus, a normal vector $\bar{N}$ to the plane in which the locus of the mid-points of the circular cross sections lies, and the scalars R_1, the distance from the center $\bar{V}$ to the mid-point of the circular cross-section, and R_2, the radius of the circular cross-section.

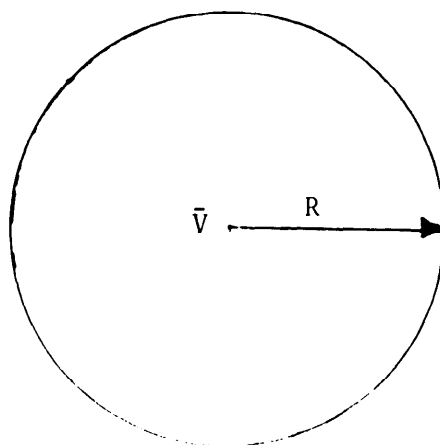NOTE: The first solid on Table 2 is a TOR.
*Card Columns 71-80 are used for comments.
Card Format: (A1, A2, A3, A4, 6F10.5, 2A5).

CARD COLUMNS*

1-3	4-6	11-20	21-30	31-40	41-50	51-60	61-70	Number of Cards
Solid Number	TOR	Vx	Vy	Vz	Nx	Ny	Nz	1 of 2
Solid Number		R_1	R_2					2 of 2

Figure 20. Torus (TOR) Input

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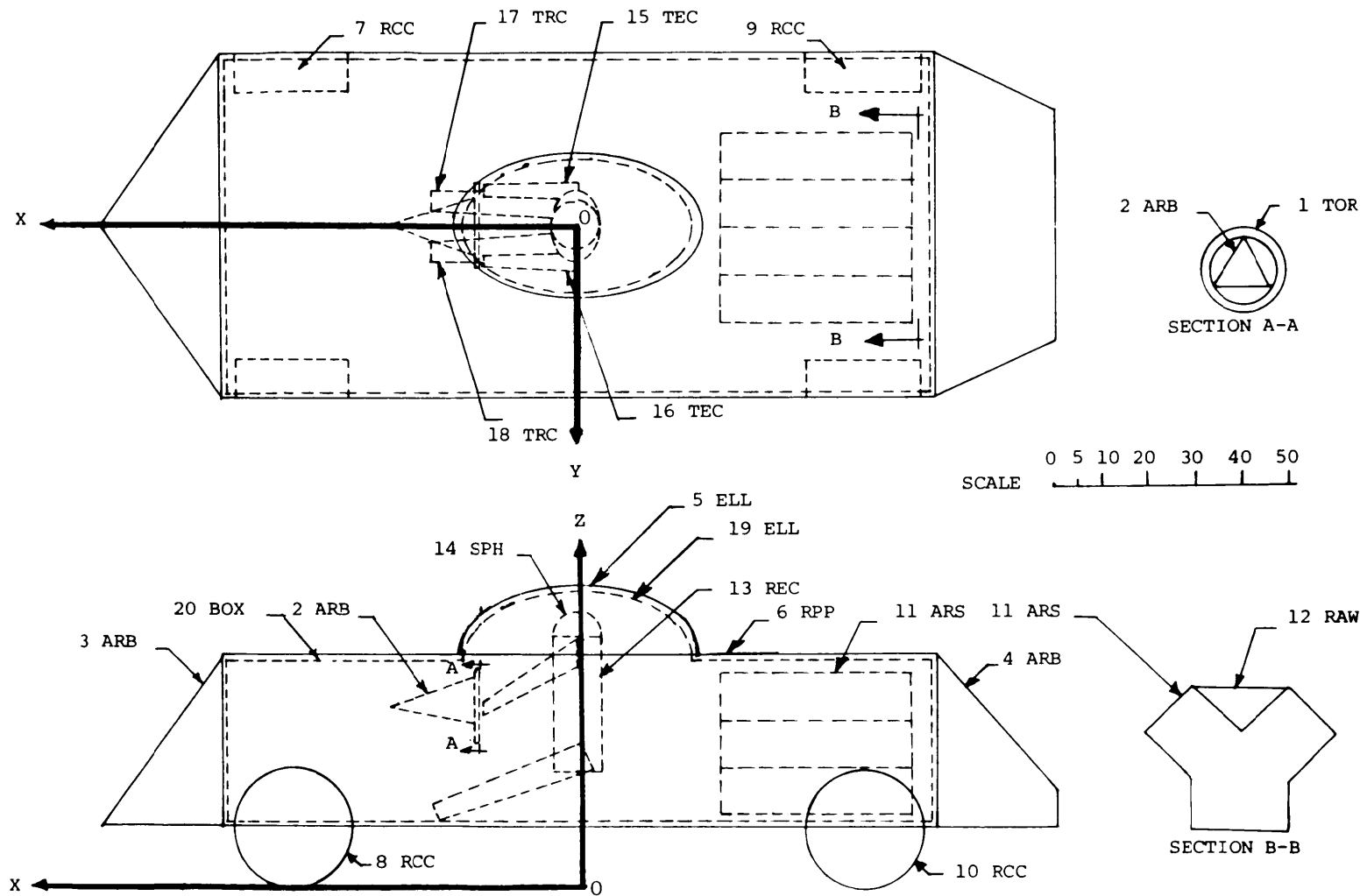
Figure 21. X,Y,Z Coordinates Superimposed Over the Engineering Drawings
of a Sample Target

Table 2 presents the input parameters of the solids used to describe the sample target. The solid parameters recorded on Table 2 are measurements taken from Figure 21 using the origin point and the unit scale illustrated on the figure. Using Figure 21 and attempting to duplicate the values of the solid parameters recorded within Table 2 will help clarify the input parameters required for the different solid types.

2.3 Solid Table

A Solid Table contains the input cards for every solid used to describe the target. Table 2 is the Solid Table for the sample target. Twenty solids are used to describe the sample target.

As the BOX and two SPH's on Figure 4 were given a unique number to identify these solids, every solid within a Solid Table must have a unique number. The numbering of the solids in the Solid Table begins with the number "1" and is consecutive (1, 2, 3,...,). No hierarchy exists between the solids; any solid type can be numbered "1, or 2, or 3,..."

2.4 "Combination" of Solids

The three-dimensional shape and space of several solids can be "combined" to define a component of a target. Figure 22 illustrates the concepts of "intersection," "subtraction," and "union" which are used to "combine" the space of several solids.

Section A of Figure 22 exhibits an RPP and SPH which overlap. For discussion, suppose that the RPP is the first solid in a Solid Table; it is therefore numbered "1". If the SPH is the second solid in the Solid Table, it is therefore numbered "2". The "intersection" (+) of the RPP (1) and the SPH (2) solid is represented as "1 + 2". The "1 + 2" symbolization may be interpreted as the space of the first (1) solid in the Solid Table that overlaps or "intersects" (+) the space of the second (2) solid in the Solid Table. The dashed (/) area in section B of Figure 22 represents the space of "1+2", the space of the RPP (1) that overlaps the space of the SPH (2).

The "Subtraction" (-) of the space of the SPH (2) from the space of the RPP (1) is represented by "1-2". The "1-2" symbolization may be interpreted as the space of the first (1) solid removing or "subtracting" the space of second solid in the Solid Table. The dashed area in section C of the Figure 22 represents the space of "1-2", the space of the RPP removing the space of the SPH. Note that the space resulting from "1 + 2" and "2 + 1" (intersect relationship) would be the same; however, "1 - 2" results in a space different from "2 - 1", the space of the SPH removing the space of the RPP.

Table 2. Solid Table for the Sample Target

#	Name							Label
1	TOR	21.5	0.	37.	1.	0.	0.	STEERING
1		8.0	1.0					WHEEL
2	ARB4	21.5	-6.	33.5	21.5	6.	33.5	CENTER
2		21.5	0.	44.	40.	0.	37.	STEERING
3	ARB5	75.	-36.	12.	75.	36.	12.	FRONT
3		75.	36.	48.	75.	-36.	48.	3-2
3		100.	0.	12.				3-3
4	ARB8	-75.	-36.	12.	-75.	36.	12.	REAR
4		-75.	36.	48.	-75.	-36.	48.	4-2
4		-100.	-24.	12.	-100.	24.	12.	4-3
4		-100.	24.	20.	-100.	-24.	20.	4-4
5	ELL	20.	0.	48.	-20.	0.	48.	BUBBLE
5		50.						
6	RPP	-75.	75.	-36.	36.	12.	48.	BODY
7	RCC	60.	-36.	12.	0.	8.	0.	WHEEL
7		12.						
8	RCC	60.	36.	12.	0.	-8.	0.	WHEEL
8		12.						
9	RCC	-60.	-36.	12.	0.	8.	0.	WHEEL
9		12.						
10	RCC	-60.	36.	12.	0.	-8.	0.	WHEEL
10		12.						
11	ARS	6		5				ENGINE
11		-30.	-10.	15.	-30.	-10.	15.	11-2
11		-30.	-10.	15.	-30.	-10.	15.	11-3
11		-30.	-10.	15.				11-4
11		-30.	-10.	15.	-70.	-10.	15.	11-5
11		-70.	10.	15.	-30.	10.	15.	11-6
11		-30.	-10.	15.				11-7
11		-30.	-10.	25.	-70.	-10.	25.	11-8
11		-70.	10.	25.	-30.	10.	25.	11-9
11		-30.	-10.	25.				11-10
11		-30.	-20.	35.	-70.	-20.	35.	11-11
11		-70.	20.	35.	-30.	20.	35.	11-12
11		-30.	-20.	35.				11-13
11		-30.	-10.	45.	-70.	-10.	45.	11-14
11		-70.	10.	45.	-30.	10.	45.	11-15
11		-30.	-10.	45.				11-16
11		-30.	-10.	45.	-30.	-10.	45.	11-17
11		-30.	-10.	45.	-30.	-10.	45.	11-18
11		-30.	-10.	45.				11-19
12	RAW	-70.	0.	35.	0.	-11.	11.	(ENGINE)
12		0.	11.	11.	40.	0.	0.	
13	REC	0.	0.	24.	0.	0.	28.	TRUNK
13		0.	7.5	0.	5.	0.	0.	
14	SPH	0.	0.	52.	5.			HEAD
15	TEC	0.	-7.5	49.	20.	0.	-12.	ARM
15		0.	0.	3.	0.	2.	0.	15-2
15		2.						15-3
16	TEC	0.	7.5	49.	20.	0.	-12.	ARM
16		0.	0.	3.	0.	2.	0.	16-2
16		2.						16-3
17	TRC	-2.	-4.5	27.	32.	0.	-12.	LEG
17		3.	2.					
18	TRC	-2.	4.5	27.	32.	0.	-12.	LEG
18		3.	2.					
19	ELL1	0.	0.	48.	24.	0.	0.	(1.0)
19		14.						
20	BOX	-74.	-35.	13.	148.	0.	0.	(1.0)
20		0.	70.	0.	0.	0.	34.	

RPP(1)

SPH(2)

A.

INTERSECTION

1 + 2

B.

SUBTRACTION

1 - 2

C.

SUBTRACTION

2 - 1

D.

UNION

1 OR 2

E.
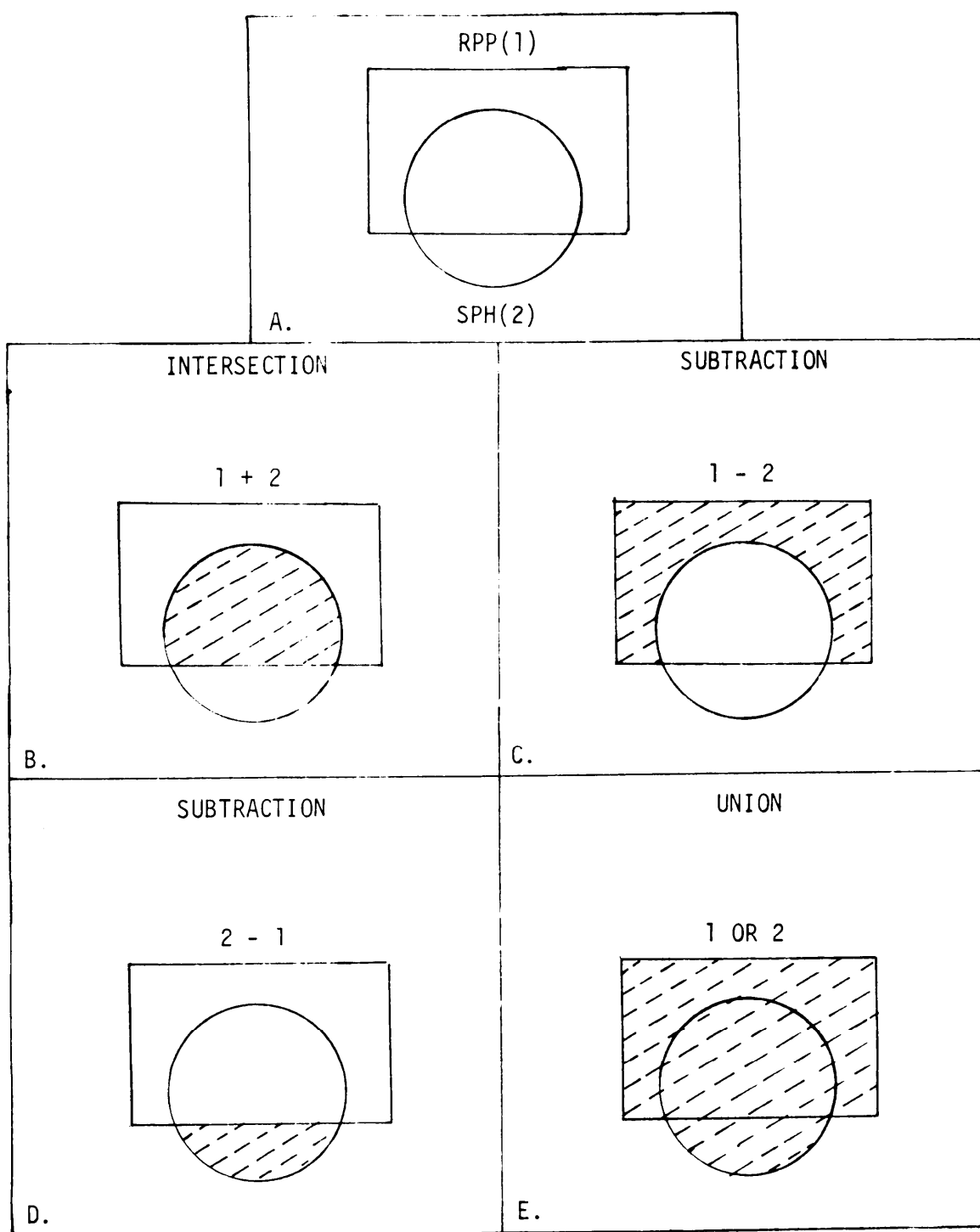
Figure 22.   Intersection, Subtraction and Union Between Two Solids

The "union" (OR) of the space of the RPP (1) and the SPH (2) is
represented by "1 OR 2". The "1 OR 2" symbolization is the space of the
first (1) solid "and" or "union" (OR) the space of the second solid (2)
in the Solid Table. The dashed area in section E on Figure 22 repre-
sents "1 OR 2", the space of the RPP "and" the space of the SPH. As
the intersect relationship, the union relationship of "1 OR 2" and
"2 OR 1" results in the same space.

To model irregular shaped components of a target may require the
intersection, subtraction, and union of many different solids. In
section A on Figure 23 a third solid (numbered "3") has been added to
the RPP and SPH configuration used in Figure 22. The third (3) solid
may be a BOX or another RPP.

The dashed area in section B of Figure 23 represents the space
resulting from the intersection of solids 1, 2, and 3 (1+2+3). A
process to arrive at the results of "1+2+3" is to visualize the area
resulting from "1+2" (shown in Figure 22) and then find the intersect
(+) of the third (3) solid with the area from "1+2".

The dashed area in section C of Figure 23 represents the space
resulting from the relationship "3-1", the space of the third (3)
solid removing or subtracting the space of the first (1) solid.

The dashed area in section D represents the space resulting from
"1+2-3". Again analyzing the final space by steps: first, visualize
the "1+2" relationship, then remove or subtract the space of solid "3".

The dashed area in section E represents the space resulting from
"1 OR 2 OR 3".

The dashed area in section F represents the space of "1+2-3 OR 3-1".
Note that the space of "1+2-3 OR 3-1" shown in section F is the union
of the spaces represented in sections D and C. In section F, the OR
symbol separates the "1+2-3" portion from the "3-1" portion. The solids
and relationships of the first portion (1+2-3) do not influence the
solids and relationships of the second portion (3-1).

2.5 Region Table

For every component of the target which is being modeled, a
region card(s) defines the shape and space of the component as a single
solid or combination of several solids. On the region cards, the
solids are referred to by their unique solid number and the combination
symbols "+, -, OR" are used. The set of region cards which defines the
components of the target is called the "Region Table." Figure 24
displays the input format for the region card(s); a printout of the in-
put cards required for a sample region (111); and a printout of the
region cards that comprise the Region Table for the sample target.

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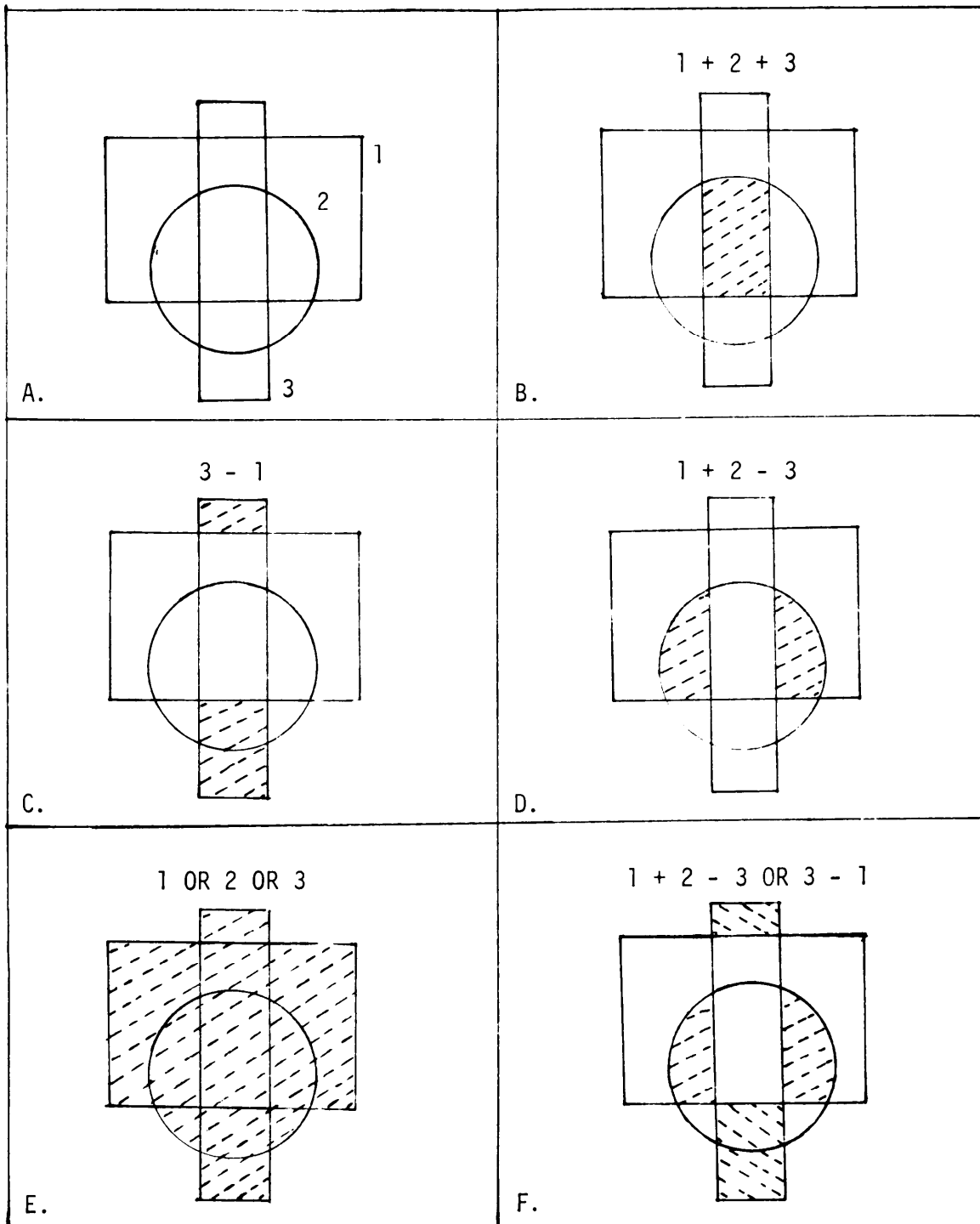
Figure 23. Intersection, Subtraction and Union Between Three Solids

Card Columns

1-5	7-8	9-13	14-20	21-27	28-34	35-41	42-48	49-55	56-62	63-64	65-69	70-80
Region Number	OR	(±) Solid Number	*	*	*	*	*	*	*	OR	(±) Solid Number	Comments

FORMAT: (I5, 1X, 9(AZ, I5), A1, 2A5)

*The first two card columns are reserved for OR if necessary, while the remaining five card columns are used for (±) Solid Number. For example: card columns 14 and 15 are for OR if needed while columns 16-20 are used for (±) Solid Numbers.

SAMPLE REGION INPUT FOR   1+2-3 OR 4 OR 5+6-7-8 OR 9-10+11+12 OR 13

```
111 OR    1        2       -3OR     4OR     5        6       -7      -8OR     9      111-1
         -15       11      12OR    13                                                111-2
```

REGION TABLE FOR SAMPLE TARGET

```
 1     1     -2
 2     2
 3     3
 4     4
 5     5     -6     -19
 6     6    -20    -19      -7      -8      -9     -10
 7     7
 8     8
 9     9
10    10
11    11    -12
12
13    13    -15    -16     -17     -18
14    14    -13
15    15
16    16
17    17
18    18
19    19
20    20
-1
```

Figure 24. Card Input for the Region Cards and the Region Table for Sample Target

The regions in the Region Table, as the solids within the Solid Table, are numbered consecutively; the first region is numbered "1", the second number "2", the third numbered "3", etc.

On Figure 24, the sample region is numbered "111", implying that it is the one hundred and eleventh region in some Region Table. Two region cards are required to define our sample region "1+2-3 OR 4 OR 5+6-7-8 OR 9-10+11+12 OR 13". Any number of region cards may be required to define a region; however, only the first card contains the region number. Note that the region number "111" appears in card columns 3, 4, 5 only on the first card.

Card columns 70-80 (comments) on the region card may include any comments, but including an identification of the card is recommended when more than one card is required to define a region. For example, the comments "111-1" and "111-2" in columns 70-80 on the sample region cards mean "111" first (1) and second (2) card, respectively.

When the "OR" relationship is used in the definition of a region, "OR" must be punched in card columns 7-8 on the first region card. Note the "OR" after "111" on the first region card for sample region. The sample region reads: "OR 1+2-3 OR 4..." which is the same as "1+2-3 OR 4..."; the introductory "OR" indicates to the GIFT code that the "OR" relationship will be used in the description of the region.

On the region cards, the "+" symbol need not be punched. Reviewing the region cards for region 111 and the Region Table for the sample target, note that no "+" symbols are used. A non-punch or blank before a solid number implies the intersection (+) relationship.

There are twenty regions in the Region Table for the sample target, and the region numbers in the table are consecutive (1 to 20). The last card (after region number "20" card) in the Region Table contains "-1" in card columns 4 and 5. The "-1 CARD", as it is called, is the flag or mark that indicates the end of the Region Table and must follow the Region Table.

2.6 Recommended Procedures for the Region Table

The Solid Table for the sample target contains twenty solids and the Region Table contains twenty regions. The number of solids and the number of regions may be different; however, experience gained from modeling targets containing many solids has proven the usefulness of the following scheme. Note that region number "1" in the Region Table for the sample target begins with the solid number "1"; region number "2" begins with solid number "2"; region "3" with solid "3" ... region "20" with solid "20". Only region number "12" does not follow the pattern. In fact, region "12" sans any solid numbers is called a "dummy region" because no space is defined by the region. In a Region Table any number

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of "dummy regions" like region "12" may be used. A "dummy region" is a region card containing only a region number. Because the regions must be numbered consecutively, the purpose of region "12" is to maintain the pattern of region "13, 14, 15 ... 20" beginning with solid number "13, 14, 15 ... 20". When the region number is equal to the first solid number, it is easy to locate the components of the modeled target, to correct errors, and to modify the Solid and Region Tables. Using "dummy regions" and having the first solid and region number for non-dummy regions equal is recommended.

The Region Table for the sample target does not contain any "OR" or union relationships. The OR relationship between solids may be used but its usage is not recommended. (Section 2.9 of this report presents a technique which is logically equivalent to the "OR" relationship).

2.7 Region Identification Table

The Region Identification Table assigns an identification (code) number to each region in the Region Table. Table 3 exhibits a grouping of identification numbers from 1 to 998 used to identify the components of military vehicles - tanks, trucks, etc. Numbers from 1 to 99 are assigned to the regions in the Region Table which represent "personnel and miscellaneous interior components"; numbers from 100 to 199 are assigned to the regions in the Region Table which represent "armor and vehicle structure components";...; numbers from 900 to 998 are used to identify the regions in the Region Table which represent components that are "ammunition."

Regions in the Region Table may also define spaces which represent air within and around a target or vehicle. For example, regions may define the air space where the crew members of a vehicle are (crew compartment air), the air space where the passengers are, and the air space surrounding the engine of the vehicle. Respectively, the identification numbers "02", "03" and "05" (shown on Table 3) are assigned to these air spaces.

Figure 25 presents the card input format and a printout of the Region Identification Table for the sample target. On the input cards, the region number is followed by either a component (item) or an air space identification (code) number; a region either models an item or it models an air space. In the Region Identification Table, regions 19 and 20 are identified as "02" air spaces, while region numbers 1 to 18 have item numbers. For example, Region 1 has been identified by component number "40", and represents the "steering wheel" as the comments on the region identification card indicate. The "1-2", also contained in the comment section of this card, is the Region Table description of region 1 where solid 1 is a "TOR". (The verbal and region description, and the solid type are contained in

Table 3.   Identification Numbers Used for Vehicles

IDENTIFICATION NUMBERS FOR COMPONENTS OF A VEHICLE.

      1 TO   99   PERSONNEL AND MISCELLANEOUS INTERIOR COMPONENTS.
    100 TO 199   ARMOR AND VEHICLE STRUCTURE COMPONENTS.
    200 TO 299   FUEL STORAGE AND SUPPLY SYSTEM COMPONENTS.
    300 TO 399   MISCELLANEOUS EXTERIOR COMPONENTS.
    400 TO 499   ARMAMENT (NOT AMMO) SYSTEMS COMPONENTS.
    500 TO 599   TRACK SUSPENSION SYSTEM COMPONENTS.
    600 TO 699   WHEEL SUSPENSION SYSTEM COMPONENTS.
    700 TO 799   ENGINE TRANSMITTION AND OTHER POWER COMPONENTS.
    800 TO 899   ENVIRONMENT AND SAFETY COMPONENTS.
    900 TO 998   AMMUNITION.
   * 501   USE FOR TRACK ONLY. CODE GENERATES 5 & FOR TRACK EDGE.
   * 111   USE FOR DUMMY REGIONS.
   * 999   NEVER USE. SPECIAL NUMBER FOR GIFT CODE.

IDENTIFICATION NUMBERS FOR AIR REGIONS.

       1   AIR IN GENERAL. CODE ASSIGNS '0' TO DESCRIPTION GAPS.
       2   CREW COMPARTMENT AIR FOR VEHICLES.
       3   PASSANGER COMPARTMENT AIR FOR VEHICLES.
       5   ENGINE COMPARTMENT AIR FOR VEHICLES.
     10 TO 98   MAY USE. NO SPECIAL USAGE DEFINED.
      * 99   NEVER USE. SPECIAL NUMBER FOR GIFT CODE.

   *SPECIAL USAGE IDENTIFICATION NUMBERS.

Card Columns

1-10	11-20	21-30	31-40	41-80
Region Number	Item Code Number	Air Space Code Number		Alphameric Description of the Region

REGION IDENTIFICATION TABLE FOR SAMPLE TARGET

```
 1      40                            STEERING WHEEL       1-2                  TOR
 2      41                            STEERING SHAFT       2                    ARB4
 3      100                           BODY-FRONT           3                    ARB5
 4      133                           BODY-REAR            4                    ARB8
 5      111                           BUBBLE               5-6-19               ELL
 6      100                           BODY-CENTER          6-20-19-7-8-9-10     RPP
 7      651                           WHEEL RIGHT FRONT    7                    RCC
 8      652                           WHEEL LEFT  FRONT    8                    RCC
 9      653                           WHEEL RIGHT REAR     9                    RCC
10      654                           WHEEL LEFT  REAR     10                   RCC
11      701                           ENGINE               11-12                ARS
12      111                           DUMMY REGION         0                    RAW
13      31                            MAN-TORSO            13-15-16-17-18       REC
14      31                            MAN-HEAD             14-13                SPH
15      31                            MAN-ARM              15                   TEC
16      31                            MAN-ARM              16                   TEC
17      31                            MAN-LEG              17                   TRC
18      31                            MAN-LEG              18                   TRC
19              32                    INSIDE AIR (BUBBLE)  19                   ELL1
20              32                    INSIDE AIR (BODY)    20                   BOX
```

Figure 25. Card Input and the Region Identification Table for the
Sample Target

the comment section of the region identification cards for the other regions.) Comments should verbally describe and define the component or air space that the region models.

The user is not required to define any air spaces in the Region and Region Identification Tables. Air spaces are defined if the user wants to identify special air spaces within and around the target such as the crew and engine compartment air. Regions 19 and 20 of the sample target identify the air space (02) inside of the sample target (car). Regions 19 and 20 were included to illustrate air space usage; otherwise, regions 19 and 20 may have been omitted from the Region and the Region Identification Tables.

2.8 Special Region Identification Numbers

On Table 3 certain identification numbers are followed by an asterisk (*); these identification numbers have specific meanings. Never use number "999" to identify a component and never use "09" to identify an air space.

The number "111" is used to identify the "dummy regions" in the Region Table. For example, for the sample target, region 12 is a dummy region; thus, it is identified by the special number "111". The last special identification number is "501"; this number is only used to identify regions that model the tracks of tracked vehicles. The "501" number is sometimes converted by the GIFT code into "502", which indicates the edge of the track.

Users of the GIFT code may use the identification system shown on Table 3 or develop an original grouping scheme, but the usage of the special numbers (501, 111, 999 and 01 air) cannot change.

2.9 Using Identification Numbers to "Combine" Regions

On Figure 25, note that regions 13 to 18 have a common identification number (31), while regions 3, 4 and 6 have a common identification number (100). Regions with a common identification number are "combined" as the "OR" relationship combines solids. For example, because regions 13 to 18 are identified by the same code number (31), these regions are equivalent to the following single region: "13-15-16-17-18 OR 14-13 OR 15 OR 16 OR 17 OR 18".

It is recommended that the user not use the "OR" relationship, but use common identification numbers to combine regions. There are several reasons why it is more desirable to use the same identification numbers for several simple regions rather than use the OR relationship to create one large region. The computer run-time is increased when the OR relationship is used. It is easier to locate the parts of a

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component when they are defined by several regions with the same identification number. For example, regions 13 to 18 define the different parts of the man or the driver of the sample vehicle. If a user wanted to place a helmet on the man's head, the man's head is quickly identified to be region "14". If regions 13 to 18 were grouped into a single region by using the OR relationship, it would be harder to locate the head of the man. A user may be required to identify the different parts of the man such as his head, legs, arms, and torso. The users would only have to assign unique identification numbers to regions 13 to 18. If the man was a single region using the OR relationship, the user would be required to identify the parts of the man and then create new regions and region identification cards. The problems associated with the use of the OR relationship expand as the complexity of the target increases; therefore, it is recommended that the OR relationship not be used.

2.10 Rules for Regions

The Region Identification Table defines each region in the Region Table as either a component or an air space. Rules exist for regions that model components or items, while different rules apply for regions that define air spaces. Figure 26 provides illustrations for the rules of the regions.

Section A of Figure 26 exhibits two regions: R1 is a BOX and R2 is an SPH. The SPH and BOX are shown to overlap: the area of overlap contains dashed (/) lines. The three-dimensional SPH and BOX solids are represented on a two-dimensional plane; thus it is assumed that in depth they also overlap. If R1 is defined to be the space of the BOX, while R2 is the space of the SPH in a Region Table, and if R1 and R2 were identified in the Region Identification Table as components or items, then the only rule for regions that model components is violated - REGIONS THAT MODEL COMPONENTS CANNOT OVERLAP. In the physical world components cannot overlap or share a common space; thus, R1 and R2 cannot overlap if they model physical components. Regions that model components and overlap indicate errors either in the Solid Table data or in the Region Table data.

If R1 is the space of the BOX while R2 is the space of the SPH, and if R1 and R2 are identified as items, then they must be correctly defined in the Solid Table to assure that they do not overlap. It may be impossible to measure and record the BOX, SPH, or any solid parameters accurately enough to assure that the solids do not overlap. If the overlap is small, the user can modify the model of the regions: R1 can be redefined to be the BOX subtract or less (-) the space of the SPH, removing the space of the SPH that overlaps the BOX from the model of the BOX; or R2 can be modified in similar manner to remove the overlap space of the BOX from the SPH. Solids can overlap, but regions identified as components cannot. In the next section of this report, it will be explained how the user can specify the amount of overlap between solids to be ignored by the GIFT code.
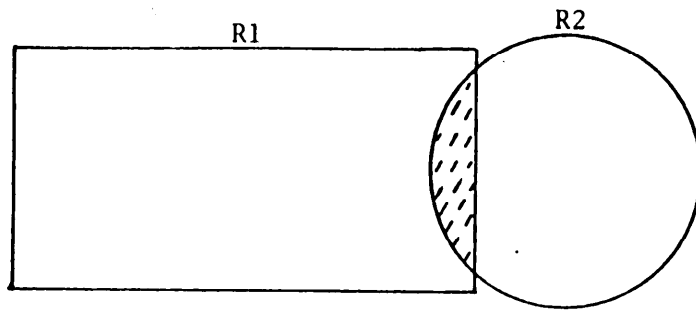
Section A
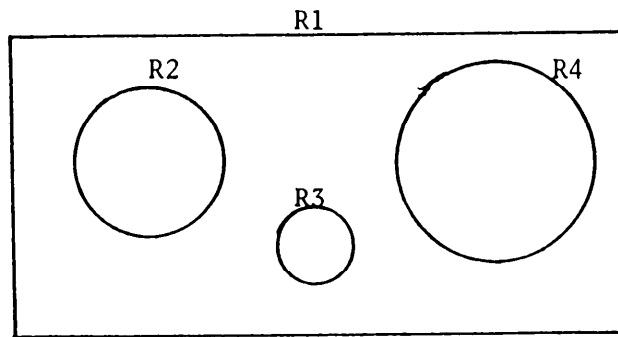
Section B
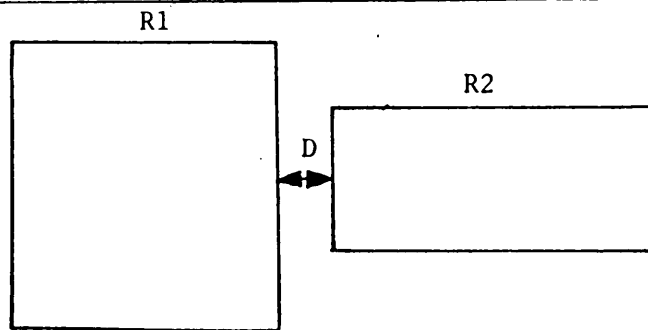
Section C

Figure 26. Illustrations for Region Rules

Section B of Figure 26, displays four regions: R1 is a BOX while R2, R3 and R4 are SPH's. The rules for regions identified in the Region Identification Table as air spaces are different from the rules of the regions identified as components. If R1 is identified in the Region Identification Table as an air space while R2, R3 and R4 are identified as components, then region R1 can be defined as the space of the BOX. REGIONS IDENTIFIED AS AIR SPACES CAN OVERLAP ANY REGIONS IDENTIFIED AS COMPONENTS. Imagine R1 as a BOX that defines the air in a rectangular room, while R2, R3, R4 are components within the room. The BOX or R1 would define the space of the air in the room and R2, R3, R4, would be components within the air space (R1) of the room. If R1, R2, R3, and R4 were all identified in the Region Identification Table as components, then to avoid overlap R1 would have to be defined as the space of the BOX less or subtracting (-) the solids that define the space occupied by regions R2, R3, and R4.

Examining the Solid Table, the Region Table and the Region Identification Table for the sample target, note that both regions 19 and 20 are identified as 02 air space and the spaces defined by regions 19 and 20 overlap each other. REGIONS IDENTIFIED AS AIR SPACES CAN OVERLAP REGIONS WITH THE SAME AIRSPACE IDENTIFICATION CODE NUMBER.

REGIONS WITH AIRSPACE CODE NUMBERS CANNOT OVERLAP REGIONS WITH DIFFERENT AIR SPACE CODE NUMBERS. If region 19 of the sample target was identified in the Region Identification Table with any air space code number other than 02, and region 20 retained its 02 code number, then regions 19 and 20 could not overlap.

2.11 GIFT Code Memory Requirements and Region Tolerances

Table 4 is a printout of portions of the CDC 6600 version of the GIFT code. The code lines or cards discussed in this section are also in the IBM and UNIVAC version of the GIFT code. On Table 4, four arrows (▶) point to the four specific lines within the GIFT code that specify the memory size and region tolerances for the target description data.

Lines "COMMON ASTER (5000)" and "NDQ=5000" specify the amount (5000) of words of memory storage reserved for the target description data: Solid, Region, Region Identification Tables, and other geometric data that are stored in the computer's core memory. The memory size required for a given target description is difficult to compute because a large number of factors must be considered. A crude estimate of the amount of memory words of storage required is 45 times the number of solids in the target description data.

The "5000" memory words indicated on the printout is large enough for the sample target; however, the "5000" words would not be large enough for a target description containing hundred of solids and regions. If a target description has 1000 solids, then 45 times the

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Table 4. Printout of Selected Portions of the GIFT Code

```
      PROGRAM GIFT(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,
C    +        TAPE1,TAPE2,TAPE4,TAPE10)
C         THIS IS A PSEUDO MAIN PROGRAM TO SET SIZE OF GEOMETRY
C         STORAGE IN BLANK COMMON
C
►     COMMON /SIZE  / LDUM,NDQ
►     COMMON ASTER(5000)
►     NDQ=5000
      CALL GIFTM
      STOP
      END
C
C
      SUBROUTINE GIFTM
C
C     GIFT PROGRAM   (GEOMETRY INFORMATION FOR TARGETS)
C     CDC VERSION
C
C
C     MAIN PROGRAM
C         READS CONTROL CARD
C         CONTROLS GEOMETRY PROCESSING
C         CONTROLS CALLING OF APPLICATION ROUTINES
```

The printout below follows the DIMENSION, COMMON and FORMAT cards
of subroutine GIFTM.

```
      LBASE=1
C         COMPUTER INFINITY
      PINF=1.0E50
C         GEOMETRY TOLERANCE
►     TOL=0.001
C         TOLERANCE FOR LINE-OF-SIGHT
►     TOLLOS=0.0001
C         INITIALIZES SOLID RPP EQUIVALENT STORAGE
      BIG=1.0E100
C         2**15 - PACKING CONSTANT
```

number of solids (1000), or 45,000 words, is a crude estimate of memory requirements. To run the 1000 solid target description, the user must change the "COMMON ASTER (5000)" line to "COMMON ASTER (45000)" and the "NDQ=5000" line to "NDQ=45000". If 45,000 words is insufficient, then one of the following statements will be outputed depending upon what data was being stored when the memory was exceeded: 1) NO MORE ROOM FOR SOLID DATA, 2) NO MORE ROOM FOR REGION DATA, 3) NO ROOM FOR IDENTIFICATION TABLE, 4) NO ROOM FOR WORKING STORAGE. Working storage is the memory required to perform the calculations for the output options of the GIFT code discussed in "The GIFT Code User Manual; Volume II, The Output Options." If one of the above statements is output, then the numeric value of the "COMMON ASTER" and "NDQ=" lines must be enlarged to store the target description data.

Section C of Figure 26 illustrates two regions, R1 and R2, and a distance "D" between the two regions. Suppose that D is a small distance between R1 and R2 that occurred because the input parameters for the solids which define R1 and R2 could not be measured and recorded accurately enough. The GIFT code allows the users to specify the gap distance "D" between item and air regions to be ignored or tolerated. Note the arrowed "TOL=0.0001" and "TOLLOS=0.0001" lines on Table 4. TOL is the overlap tolerance, while TOLLOS is the gap tolerance. The value of 0.0001 is one ten-thousandth of the unit of measurement (inches, centimeters, etc.) used in the target description model. For most target descriptions, the "TOL=0.0001" and TOLLOS=0.0001" lines are replaced by "TOL=0.01" and "TOLLOS=0.01" or one hundredth of the unit of measure is the tolerance used. The user can decide and set the numeric values of TOL and TOLLOS to be used with his target description data.

2.12 Region RPP Table

An RPP solid (see Figure 5) can be defined to enclose or contain the space or volume of any region. The minimum and maximum X, Y, and Z coordinate values (XMIN, XMAX, YMIN, YMAX, ZMIN and ZMAX) of the RPP solid that encloses a region may be interpreted as follows: The region is located between XMIN and XMAX, is between YMIN and YMAX, and is between ZMIN and ZMAX. Figure 27 presents the card input format and a printout of the Region RPP Table for the sample target.

The first card of the Region RPP Table for the sample target states that region number "1" is enclosed by an RPP with XMIN=20.0, XMAX=23.0, YMIN=-10.0,YMAX=10.0, ZMIN=28.0, and ZMAX=46.0. Note that the sample table does not include a card input for region "12" because region "12" is a "dummy region." Region "2" modeling the steering shaft or any region may be omitted from the Region RPP Table. In fact, no Region RPP Table is required because the GIFT code computes a set of enclosing RPP values (XMIN, XMAX, YMIN ... ZMAX) for any region in the Region Table not included in the Region RPP Table.

1-10	11-20	21-30	31-40	41-50	51-60	61-70
Region Number	XMIN	XMAX	YMIN	YMAX	ZMIN	ZMAX

Format: (I10, 6F10.0)

REGION RPP TABLE FOR SAMPLE TARGET

```
 1     2 .0     23..      -1C..     1C.C      28.C      46..
 2     21.0     4C..      -6..       6.C      33.0      44.0
 3     74.0     1 1..     -26.C     36..      12..      48.0
 4   -1 1.0    -74.C      -36.C     36..      12.C      48..
 5    -2 .5     2 .5      -15.5     15.5      45.C      63..
 6    -75.0     75.C      -36.C     36.C      12.0      48.C
 7     47.0     72..      -36.C    -28.C       C.C      24.0
 8     47.C     7 .5       28.C     36.C       C.C      24..
 9    -72.5    -47.C      -36.C    -28.C       C.C      24..
1.    -72.5    -47.C       28.C     36.C       C.C      24.0
11    -7 .0    -3 ..      -2C..     2C..      15.C      45.C
13     - .0      .C       -7..       7.5      24.C      52..
14     - .5      .5       -5.5       5.5      52..      57.0
1      .0       2C.C      -1C.C     -5.5      35.C      52.5
16     - .0     2 ..       5..      1C.C      35.C      52..
17     - .5     3 ..      -8.C      -1.C      12.C      30..
18     - .5     3 .C       1.C       8.C      12.C      3 ..
19    -24.5     24.5      -1 .C     1 .C      34.C      62.0
20    -75.0     75.C      -5..      35.C      13.C      47.C
```

Figure 27.   Card Input and the Region RPP Table for the Sample Target

The option to input enclosing RPP values for some or every region is provided because the GIFT code may not compute a "desirable" set of RPP values. For example, an RPP with X, Y, and ZMIN values of -200.0 and X, Y, ZMAX values of 200.0 would enclose every region of the sample target; however, the region RPP values on Figure 27 define smaller volumes or spaces and are "better fitting" enclosing RPP's and thus more desirable RPP values. For most regions, the GIFT code computes a good enclosing RPP; however, the computed enclosing RPP values for a few regions can be improved. The smaller the volume or the better fit of the RPP that encloses a region, the shorter the computer run time for the GIFT code. In "The GIFT Code User Manual; Volume II, The Output Options," the computed RPP values for the regions of the sample target will be examined for their fit around the regions.

2.13 The Title and Target Specification Cards

To complete the target description, two additional cards are required — the Title Card and the Target Specification Card. Figure 28 exhibits the card input for these cards.

The Title Card contains the name of the target, the date the model was prepared, the units of measure used in the model, and any other important information on the modeled target. Only the first 60 card columns of the Title Card are read by the GIFT code; however, card columns 61 to 80 may contain additional information on the target.

The Target Specification Card contains the number of solids and the number of regions used to model the target. Another number, the number of "surrounding" RPP's, was used to model targets before the GIFT code. The concept of "surrounding" RPP's is no longer used.

2.14 Card Order for the Target Description Input

Figure 29 presents the order of the card input for the target description data. The page number given on each card or table of cards is the page in this report where the card is defined. Note that the Region Table is followed by the "-1 Card" while a blank card follows both the Region RPP and the Region Identification Tables. If no Region RPP cards are used, the blank card indicating the end of the Region RPP Table will follow the "-1 Card". The ordered target description data for the sample target is listed on Table 5. (Since the Region RPP Table is usually not prepared, it has been omitted from Table 5.)

2.15 Program Option Card

Figure 30 exhibits the Program Option Card. The Program Option Card is the first card read by the GIFT code; thus it precedes the Title Card of the target description input. Options (a), (b), (i) and (j) on the Program Option Card will be discussed in the next section of this

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TITLE CARD

Card Columns 1 to 60
TITLE of the target, date prepared, units used, etc.

FORMAT: (6A10)

TARGET SPECIFICATION CARD

Card Columns

1-10	11-20	21-30
*Number of "surrounding"RPP's	Number of solids in the solid table	Number of regions in the region table

FORMAT: (3I10)

*This value is for target description input data prepared before the GIFT code. This allows the earlier target description data to be used with the GIFT code. For the target description data defined in this report, card columns 1-10 are left blank.

Figure 28. Card Input for the Title and the Target Specification Cards

(Blank Card)

REGION IDENT. TABLE
Page 47 —— Card indicates end of region Identification Table.

(Blank Card) —— One Card for each region.

REGION RPP TABLE
Page 54 —— Card indicates end of Region RPP Table.

-1 —— Cards for all, some of the regions or no cards.

REGION TABLE
Page 43 —— "-1" in card columns 4 and 5. Indicates end of Region Table.

SOLID TABLE
Pages 20-36 —— One or more cards as required for each region.

Page 56 —— Solid cards as required.

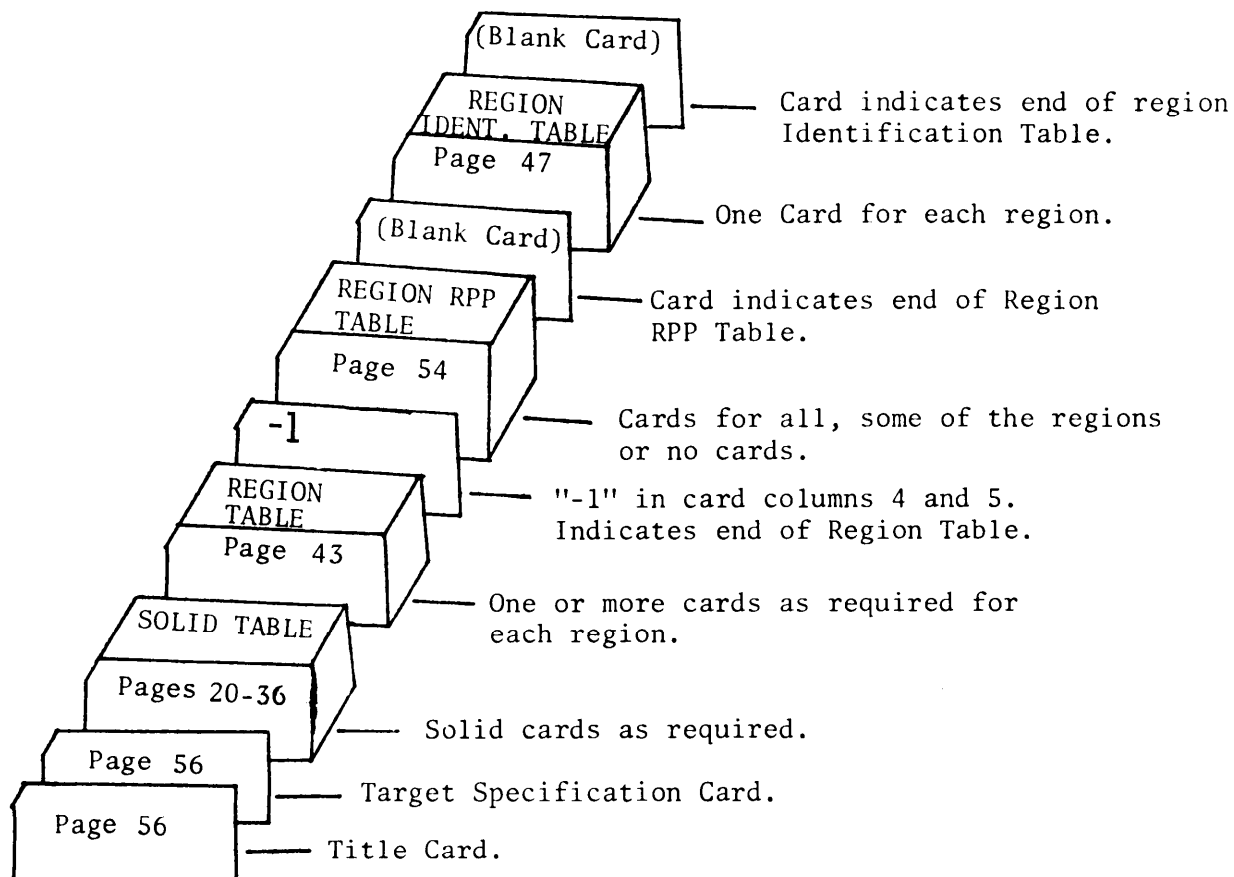Page 56 —— Target Specification Card.

—— Title Card.

Figure 29. Card Order for the Target Description Data

Table 5. Target Description Input Data for the Sample Target

SAMPLE TARGET INPUT FOR GIFT CODE   UNIT=   DATE= 1MAR74

```
                    2C          20
1  TOR    21.5    C.         37.      1.       C.       0.      STEERING
1          M.0    1.C                                           WHEEL
2  ARM4   21.5    -8.        33.5     21.5     6.       33.5    CENTER
2  ARM5   21.5    C.         44.      40.      0.       37.     STEERING
3  ARC5   75.     -36.       12.      75.      -36.     12.     FRONT
3          75.    36.        48.      75.      -36.     48.     3-2
3          10J.   U.         12.                                3-3
4  ARP8   -75.    -36.       12.      -75.     36.      12.     REAR
4          -75.   36.        48.      -75.     -36.     48.     4-2
4          -10C.  -24.       12.      -100.    24.      12.     4-3
4          -10J.  24.        2J.      -100.    -24.     20.     4-4
5  ELL    5J.     0.         48.      -20.     0.       48.     BUBBLE
5          5J.
6  RPP    -75.    75.        -36.     36.      12.      48.     BODY
7  RCC    6J.     -36.       12.      0.       8.       0.      WHEEL
7          12.
8  RCC    6J.     36.        12.      0.       -8.      0.      WHEEL
8          12.
9  RCC    -6J.    -36.       12.      0.       8.       0.      WHEEL
9          12.
10 RCC    -6J.    36.        12.      0.       -8.      0.      WHEEL
10         12.
11 ARS            6          5                                  ENGINE
11         -3C.   -1C.       15.      -30.     -1C.     15.     11-2
11         -3C.   -1C.       15.      -3C.     -1C.     15.     11-3
11         -3C.   -1C.       15.                                11-4
11         -3J.   -10.       15.      -70.     -1C.     15.     11-5
11         -7J.   1C.        15.      -30.     10.      15.     11-6
11         -3J.   -10.       15.                                11-7
11         -3J.   -10.       25.      -70.     -1C.     25.     11-8
11         -7J.   1J.        25.      -30.     10.      25.     11-9
11         -3J.   -1C.       25.                                11-10
11         -7J.   -2C.       35.      -70.     -20.     35.     11-11
11         -7J.   2C.        35.      -30.     20.      35.     11-12
11         -3J.   -2C.       35.                                11-13
11         -3J.   -1C.       45.      -7C.     -10.     45.     11-14
11         -7J.   1C.        45.      -30.     10.      45.     11-15
11         -3J.   -10.       45.                                11-16
11         -3J.   -1C.       45.      -30.     -1C.     45.     11-17
11         -3J.   -1C.       45.      -30.     -1C.     45.     11-18
11         -3J.   -1J.       45.                                11-19
12 RAW     -7J.   G.         35.      0.       -11.     11.     (ENGINE)
12         5.     11.        11.      40.      0.       0.
13 REC     5.     0.         24.      0.       0.       28.     TRUNK
13         5.     7.5        0.       5.       0.       0.
14 SPH     5.     C.         52.      5.                        HEAD
15 TEC     5.     -7.5       49.      20.      0.       -12.    ARM
15         2.     0.         3.       0.       2.       0.      15-2
15                                                              15-3
16 TEC     5.     7.5        49.      20.      0.       -12.    ARM
16         0.     0.         3.       0.       2.       0.      16-2
16                                                              16-3
17 TRC    -2.     -4.5       27.      32.      0.       -12.    LEG
17         3.     2.
18 TRC    -2.     4.5        27.      32.      0.       -12.    LEG
18         5.     2.
19 ELL1   5.      0.         49.      24.      0.       0.      (1.0)
19         14.
20 BOX    -74.    -35.       13.      148.     0.       0.      (1.0)
20         C.     7C.        0.       0.       0.       34.
```

```
 1    1                 -2
 2    2
 3    3
 4    4
 5    5      -6    -19
 6    6      -20   -19     -7     -8      -9     -10
 7    7
 8    8
 9    9
10   10
11   11   .  -12
12
13   13      -15    -16    -17    -18
14   14      -13
15   15
16   16
17   17
18   18
19   19
20   20
-1
```

```
 1       40            STEERING WHEEL          1-2            TOR
 2       41            STEERING SHAFT          2              ARM4
 3       1CO           BODY-FRONT              3              ARB5
 4       1CO           BODY-REAR               4              ARB8
 5       1C1           BUBBLE                  5-6-19         ELL
 6       100           BODY-CENTER            6-20-19-7-8-9-10 RPP
 7       651           WHEEL RIGHT FRONT       7              RCC
 8       652           WHEEL LEFT FRONT        8              RCC
 9       653           WHEEL RIGHT REAR        9              RCC
10       654           WHEEL LEFT REAR         10             RCC
11       701           ENGINE                  11-12          ARS
12       111           DUMMY REGION            0              RAW
13       31            MAN-TORSO               13-15-16-17-18 REC
14       31            MAN-HEAD               . 14-13         SPH
15       31            MAN-ARM                 15             TEC
16       31            MAN-ARM                 16             TEC
17       31            MAN-LEG                 17             TRC
18       31            MAN-LEG                 18             TRC
19              02     INSIDE AIR (BUBBLE)     19             ELL1
20              02     INSIDE AIR (BODY)       20             BOX
```

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Card Columns

1-10	11-20	21-30	31-40	41-50	51-60	61-70	71	73-75	77	78	79	80
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)

FORMAT: (7I10, I1, iX, I3, 1X, 4I1)

If a number other than zero (0) is in the card columns for options (a) to (m), then the option will be performed.

(a) Read processed target description input data from binary tape 4.
(b) Read in target description input data, process and create a binary tape 4.
(c) Perform AREA output option.
(d) Perform VOLUME output option.
(e) Perform TEST G output option.
(f) Perform MOMENT output option.
(g) Perform PICTURE output option.
(h) Perform CHECK output option.
(i) Read target description input data from tape number contained in card columns 73-75. No numeric value indicates card input.
(j) Print "Master Aster Array" of processed geometry. This helps systems analysis to debug errors within the GIFT code.
(k) Print Region Identification Table ordered by identification code numbers.
(l) Print Region RPP values ordered by X, Y, ZMIN and MAX values.
(m) Print the values of an RPP inclosing each solid.

Figure 30. Card Input of the Program Option Card

report, while the other options are output options which will be dis-
cussed in "The GIFT Code User Manual; Volume II, The Output Options."

2.16 Target Description Input via Tapes

The target description card input as shown on Table 5 may be load-
ed onto a tape. The logical unit number for the tape is specified in
card columns 73-75 or option (i) on the Program Option Card.

The first functions of the GIFT code are to read, check, process,
and store the target description data in an array called the "Master
Aster Array." If a non-zero number is in card column 77 or option (j)
on the Program Option Card, then the "Master Aster Array" will be
printed. This array is not important to users of the GIFT code, but
systems analysts can use the printout to locate errors within the GIFT
code. A non-zero number in card columns 11-20 of the Program Option Card
or option (b) will indicate that the contents of the Master Aster Array
is to be written on a binary tape logical unit 4. Once a tape unit 4 is
created, the target description data may be inputed via the created tape
4 if a non-zero number is contained in card columns 1-10 or option (a)
on the Program Option Card. Using a binary tape 4 as input eliminates
the computer time required to read in, process, and store the target
description data. Since a binary tape is hard to update or change,
a tape 4 should be created only after it is certain that the target
description input data does not contain any errors.

2.17 Errors in the Target Description Input

The target description input data for the sample target shown on
Table 5 does not contain any errors; however, incorrect parameter
values are often recorded in a Solid Table, a Region Table or the other
parts of target description input data. Incorrectly recorded values in
target description input data result in errors in the description of
the components of the target being modeled. Output options of the
GIFT code test the target description input data for errors and when an
error is detected a dianostic message is printed. These and the other
output options of the GIFT code are presented in "The GIFT Code User
Manual; Volume II, The Output Options."

3. GIFT CODE INPUT REQUIREMENTS

The target description input data described in the subsections of
Section 2 are required to perform any of the output options of the GIFT
code. Some of the output options of the GIFT code require only target
description data as input, while other output options require additional
input data. The additional input required to perform each of the differ-
ent output options of the GIFT code is described in "The GIFT Code User
Manual; Volume II, The Output Options."

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